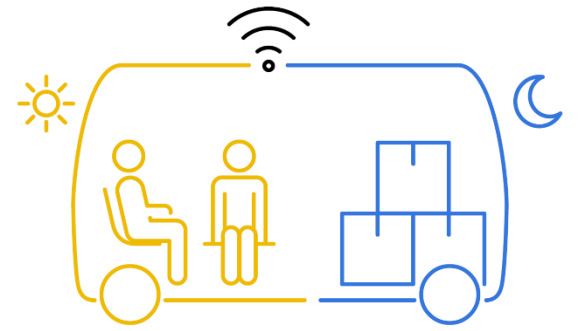

ULTIMO

Advancing Sustainable User-centric
Mobility with Automated Vehicles

DELIVERABLE

D7.7 Impact and KPI assessment – First version

Co-funded by the European Union

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1.3	28.03.2024	Christoph Glauser	Final version after internal review

Table of Contents

List of Figures

List of Tables

Acronyms

ADS	Automated Driving Systems
AI	Artificial Intelligence
AM	Automated Mobility
AMB	Automated Minibus
API	Application Protocol Interface
AV	Automated Vehicle
BMM	Business Modelling Manager
CAV	Connected and Automated Vehicles
CB	Consortium Body
CERN	European Organization for Nuclear Research
D7.7	Deliverable 7.7
DC	Demonstration Coordinator
DI	The department of infrastructure (Swiss Canton of Geneva)
DMP	Data Management Plan
DTU test track	Technical University of Denmark test track
EAB	External Advisory Board
EC	European Commission
ECSEL	Electronic Components and Systems for European Leadership
EM	Exploitation Manager
EU	European Union
EUCAD	European Conference on Connected and Automated Driving
F2F	Face to face meeting
FEDRO	(Swiss) Federal Roads Office
FM	Fleet Management
FOT	(Swiss) Federal Office of Transport
GDPR	General Data Protection Regulation
GIMS	Geneva International Motor Show
GNSS	Global Navigation Satellite System
HARA	Hazard Analysis and Risk Assessment
IPR	Intellectual Property Rights
IT	Information Technology
ITU	International Telecommunications Union
KPI	Key performance indicator
LaaS	Logistics as a Service
LIDAR	Light Detection and Ranging
MaaS	Mobility as a Service
MEM	Monitoring and Evaluation Manager
MT	MobileThinking
OCT	General Transport Directorate of the Canton of Geneva
ODD	Operational Domain Design
OEDR	Object and Event Detection and Response
PC	Project Coordinator
PEB	Project Executive Board

PGA	Project General Assembly
PRM	Persons with Reduced Mobility
PTA	Public Transport Authority
PTO	Public Transportation Operator
PTS	Public Transportation Services
QRM	Quality and Risk Manager
QRMB	Quality and Risk Management Board
RN	Risk Number
SA	Scientific Advisor
SAE Level	Society of Automotive Engineers Level (Vehicle Autonomy Level)
SAN	(Swiss) Cantonal Vehicle Service
SDK	Software Development Kit
SLA	Sales Lentz Autocars
SMB	Site Management Board
SoA	State of the Art
SOTIF	Safety Of The Intended Functionality
SWOT	Strengths, Weaknesses, Opportunities, and Threats.
T7.4	Task 7.4
TM	Technical Manager
TPG	Transport Publics Genevois
UITP	Union Internationale des Transports Publics (International Transport Union)
V2I	Vehicle to Infrastructure communication
WP	Work Package
WPL	Work Package Leader

Executive Summary

The ULTIMO project undertakes a rigorous impact-oriented approach, reflecting the Horizon Europe program's emphasis on impactful research and innovation. Initially, the project identified 151 Key Performance Indicators (KPIs), later refined to 68 through collaborative efforts among partners, ensuring relevance across social, economic, environmental, technical/performance, and governance dimensions. This KPI framework is central to measuring the project's success in integrating AVs into urban mobility and logistics services, highlighting the project's commitment to achieving quantifiable and sustainable outcomes.

This first version of the impact and KPI assessment details the ULTIMO key objectives and maps them against specific dimensions and KPIs. These objectives include validating integrated shared CCAM systems, developing open-source APIs for seamless integration, achieving large-scale multivendor deployments, creating a common model for HD maps, enhancing automated passenger services, and developing business models for dynamic chartering of AVs. Each objective is associated with targeted KPIs across the identified dimensions, illustrating ULTIMO's holistic and multidisciplinary approach to advancing automated mobility.

ULTIMO adopts an "impact-first" strategy, emphasizing user-centric and stakeholder-driven outcomes. This approach involves proactive digital impact measurements to understand user preferences and behaviours, ensuring that the project's initiatives are aligned with real-world needs and expectations. This document elaborates on the strategies for monitoring digital impact and communication efforts, aiming to maximize visibility, engagement, and relevance of the project's outputs. Through innovative techniques for content optimization and user reach analysis, ULTIMO seeks to enhance its digital footprint and foster effective stakeholder engagement. Preliminary results from digital impact monitoring underscore the relevance of ULTIMO's topics and keywords, indicating positive user engagement even in the early stages.

The multidimensional outcomes and impacts anticipated from ULTIMO are associated with specific KPIs and a framework for assessing progress towards achieving enhanced transportation efficiency, safety, user satisfaction, economic viability, environmental sustainability, and technical innovation is provided. Although comprehensive data collection will occur towards the project's conclusion, the framework sets the stage for a structured evaluation of ULTIMO's impact along a set of KPIs.

Concluding remarks emphasize the critical role of KPI assessment in gauging the project's success and guiding its trajectory, reflect on the challenges of establishing baseline values and target goals for innovative projects like ULTIMO and highlight the iterative process of aligning project objectives with measurable outcomes. The next steps involve continued data collection, analysis, and refinement of strategies to ensure the ULTIMO's objectives are met and its impacts are maximized.

1 Introduction

During the past few years many projects and initiatives were undertaken deploying and testing Automated Vehicles (AVs) for public transportation and logistics. However in spite of their ambition, all of these projects stayed on the level of elaborated experimentation and never reached the level of a large-scale commercial deployment of transport services. The reasons for this are many, the most important being the lack of economically viable and commercially realistic models, the lack of scalability of the business and operating models, and the lack of user oriented services required for large end-user adoption of the solutions.

The ULTIMO project will create the very first economically feasible and sustainable integration of AVs for MaaS public transportation and LaaS urban goods transportation. ULTIMO aims to deploy in three sites in Europe 15 or more multi-vendor SAE L4 AVs per site. A user centric holistic approach, applied throughout the project, will ensure that all elements in a cross-sector business environment are incorporated to deliver large-scale on-demand, door-to-door, well-accepted, shared, seamless-integrated and economically viable CCAM services. We target the operation without safety driver on-board, in a fully automated and mission management mode with the support of innovative user centric passenger services.

ULTIMO's innovative transportation models are designed for a long-term sustainable impact on automated transportation in Europe, around the globe and on society. The composition of the consortium ensures the interoperability between multiple stakeholders by making adoption of new technology at minimum costs and maximum safety. The integration of the ongoing experiments of previous AV-demonstrator projects ensures highest possible technical and societal impacts from the very beginning of the project, as well as during the project lifetime and even long after its completion.

1.1 On-demand Mobility

Public transportation is a key element of a region's economic development and the quality of life of its citizens. Governments around the world are defining strategies for the development of efficient public transport based on different criteria of importance to their regions, such as topography, citizens' needs, social and economic barriers, environmental concerns, and historical development. However, new technologies, modes of transport and services are appearing, which seem very promising to the support of regional strategies for the development of public transport.

On-demand transport is a public transport service that only works when a reservation has been recorded and will be a relevant solution where the demand for transport is diffuse and regular transport is inefficient.

On-demand transport differs from other public transport services in that vehicles do not follow a fixed route and do not use a predefined timetable. Unlike taxis, on-demand public transport is usually also not individual. An operator or an automated system takes care of the booking, planning and organization.

It is recognized that the use and integration of on-demand Automated vehicles has the potential to significantly improve services and provide solutions to many of the problems encountered today in the development of sustainable and efficient public transport.

1.1.1 Fully Automated Vehicles

A self-driving car, referred in the ULTIMO project as a **Fully Automated Vehicle** (**AV**), is a vehicle that can sense its environment and moving safely with no human input.

The terms *automated vehicles* and *autonomous vehicles* are often used together. The Regulation 2019/2144 of the European Parliament and of the Council of 27 November 2019 on type-approval requirements for motor vehicles defines "automated vehicle" and "fully automated vehicle" based on their autonomous capacity:

An "automated vehicle" means a motor vehicle designed and constructed to move autonomously for certain periods of time without continuous driver supervision but in respect of which driver intervention is still expected or required

"Fully automated vehicle" means a motor vehicle that has been designed and constructed to move autonomously without any driver supervision

In ULTIMO we operate ***Fully Automated mini and micro shuttles for shared public transportation***. In relation to the SAE levels, the ULTIMO project will operate SAE Level 4 vehicles.

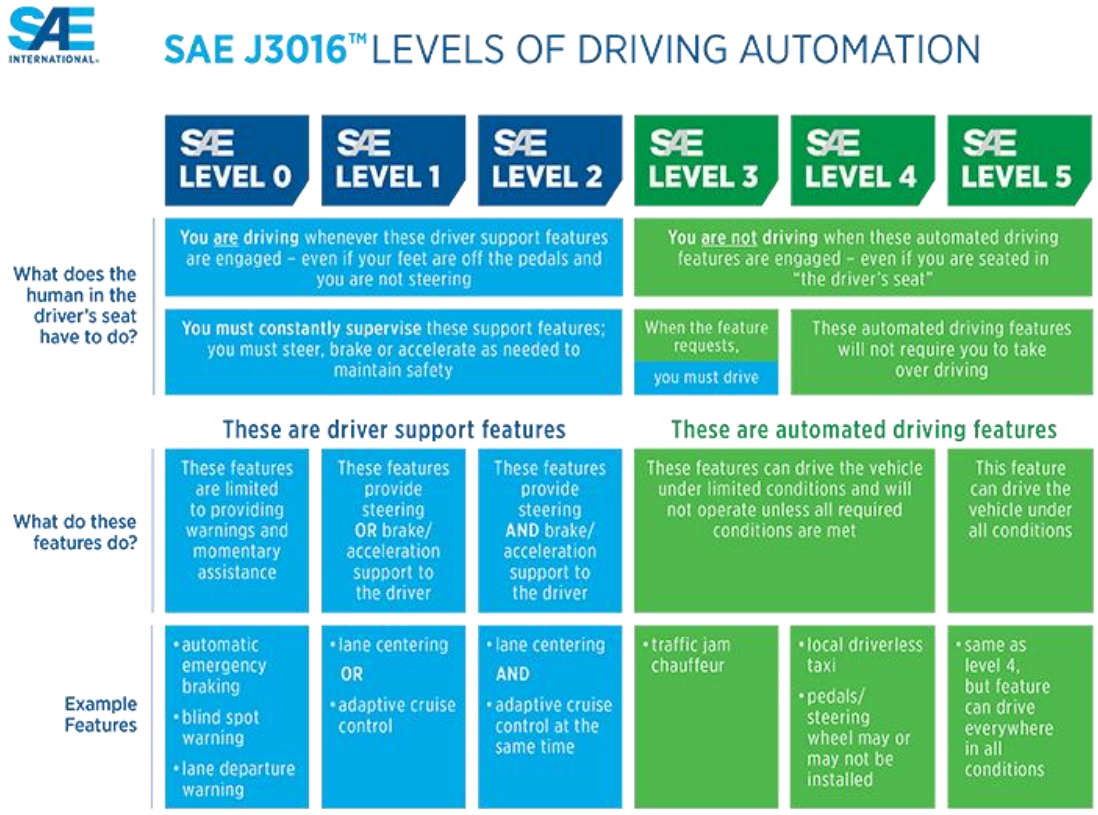

Table 1: SAE Driving Automation levels (©2020 SAE International)

1.2 The ULTIMO dream for public transportation

Our city has a population of 700.000, and the local PTO (Public Transport Operator) deploys 3.000 Km of public transportation services' routes, with 4 backbone tram lines, 8 backbone large bus/trolley lines, and 340 fully automated multi-manufacturer mini and micro-shuttles in an on-demand, door-to-door shared public transport service. The fleet of the 340 automated mini-busses is composed of different vehicle generations and models from different manufacturers, as it was purchased in different batches during the last 12 years (it all started with the first 15 bought by a European project in 2023/24). It is today composed of the first 15 twelve-years old vehicles from manufacturer A, 160 eight-years old vehicles from manufacturer B and 160 two-years old vehicles from manufacturer A, which are the new generation of manufacturer's A vehicles. These last 160 vehicles re-placed the last 70 old, driver based, thermic busses that reached the end of their life after 18 years in operation. The change from driver large busses to automated mini-buses and from fixed line service to on-demand, door-to-door, for the last area of the city, was decided 6 years ago, and was based to the great success of the already deployed AV-based services in the other parts of the city.

The integration of new vehicles in the PTO fleet was done within just a few days, thanks to the now standardised APIs of the automate vehicles' connection with the AV fleet management and orchestration service, that allows a plug-and-operate functionality, but also enables the combination of AVs with all other means of transport, offering a seamless citizen centric journey to the users. Similarly, the now standardized High Definition (HD) maps between the vehicle manufacturers, allowed us to reuse the maps created in the past for the 3.000 Kms of routes of the city, with small adaptations for the new vehicle capabilities. At the same time of the purchase of the last 160 AVs, we also switched to a new AV fleet management and orchestration service, from another provider, which offers more precise trip time estimations, considering also traffic jams in the city and weather conditions (that affect traffic in the city). The replacement was made within just two weeks, thanks to the new standardised interfaces between AV fleet management and PTO MaaS services.

Passengers are now able to reserve, via their mobile phone app, on the fly or with pre-reservation trips from one side of the city to another, using the optimal transport mode available for them, with a combination of different transport modes, and having the automated vehicle arriving next (or almost) to their door entrance and bringing them to their final destination or to a backbone transport connection. All trips are offered with highly reliable and accurate transport and arrival times, based on real time, dynamic route changes of the vehicles, responding to the passenger needs. Many passenger services are available in the AVs via a mobile phone app, adapted to all passengers' needs, from special needs passengers (visually impaired, wheel-chair users, pregnant women, elderly, children), to persons transporting suitcases or a baby-stroller, providing adapted information of their trip (where to get-off, PTO general information, and even infotainment, like city related information and historical facts and anecdotes, related to their current position).

With the full suppression of on-board operators, automated in-vehicle monitoring provides a multitude of passenger services, which were, and are developed with a continuous collaboration and innovation between users and the PTO. An on-board unit identifies locally (that is, in the bus) incidents and events, like aggressions, vandalism, forgot-ten objects, littering, accidents, etc., and raises incident alarms to the PTO back-office. The PTO officer at

the back-office evaluates the incident and decides, based on the operator policies, what action to take: dismiss the incident, or stop the vehicle and call one of the intervention teams to go the vehicle and take the required action. The back-office operator, based on the number of incidents and intervention time legal obligations, can deploy any of the 15 intervention teams available in the city, ready to reach within a few minutes any AV. At the back-office, service operators are able, with one set of screens linked to the fleet management, to follow the vehicle status, trip reservations, routes chosen, open and closed road segments (due to works, accidents, etc. thus adapting dynamically the trip routings), while in a second set of screens, the back-office operators can follow the passenger services' incidents and the status and location of the intervention teams. The two systems, although independent, are linked so that the back-office operator can transfer incidents to intervention teams and turn-on, when possible and under the local legal restrictions, video connection to inspect the incident.

The public transport services are operating 24/7 with different active vehicles, de-pending on passenger transport demands. The PTO, being eco-sensible, has defined that the vehicle must have an average occupancy of at least 3 passengers. This of course has implications, especially in off-peak hours, in the transport delays, but it is fully justified for an optimal and eco-responsible operation. Exceptions are made for people with special needs or when the passenger is ready to pay an additional price.

While at peak-hours the full 340 strong fleet of AVs is in service for public transportation, in the off-peak and night hours, due to the reduced transportation needs, part of the fleet is not serving passenger transportation. However, because having a vehicle waiting idly is a waste of resources, the PTO has signed an agreement with Logistics as a Service (LaaS) Service providers. During the off-peak hours the unused vehicles are dynamically chartered by the different LaaS providers to be used for other types of incidental transport of goods or even non-public transportation of passengers. Local shops and enterprises use the service, on demand with dynamic reservation, to offer home delivery of on-line purchases, or B2B delivery of goods from an urban consolidation center to the distribution center (hub, many to one or one to many [7], or even transport their VIP customers directly to their offices or exposition centers. This way they can deliver the goods to their customers in the city, with a delay of just 60 minutes with affordable prices, as the last mile is the most inefficient part of the goods delivery chain. The goods send can include books from local bookshops or libraries, supermarket bags or even documents exchanged between companies or waste. The local shops are even using the service in the early hours (5 o'clock in the morning) for re-provisioning their shops for the day. The so chartered AVs are "returned" to the PTO for public transport at the peak-hours automatically, at the end of the chartered time period..

1.3 Preamble – Impact and KPI assessment

WP7 is dedicated in the activities related to the overall project impact creation, communication, dissemination, and exploitation activities. All partners participate in the WP, each being in its relative domain, be it academic, industrial or knowledge promotion and dissemination.
This deliverable, related to T7.4, aims to provide a first version of the impact and KPI assessment of ULTIMO along a commonly created list of KPIs. This deliverable encapsulates the efforts of all partners to foster a participatory and stakeholder-driven project

environment and ensure a common understanding of the projects objectives and measures of success.

2 Impact and KPI assessment

As the **Horizon Europe** program is **entirely impact oriented and impact driven,** ULTIMO is taking this serious. To assess the success of ULTIMO, the project team of ArgYou has carefully collected in close collaboration with all the partners involved, PTOs and also with partners from previous projects like AVENUE and SHOW, all the existing baseline Key Performance Indicators (KPIs). **Originally, there were 151 KPIs** related to autonomous vehicles in public transportation in total. Partners and evaluators have agreed on **68 KPIs** as being **important/relevant for the ULTIMO project**. To allow a thorough impact assessment towards the end of the project, KPIs are usually clearly measurable numbers, figures, or rates. In some exceptional circumstances, they can also be other success factors where for example the success of a task can be measured in a "yes" or "no" form.

To establish the KPI assessment, there are **three simple original questions** to be answered:

1) **How do you measure your and the project's success?**
2) **What are the figures, you apply to measure your success?**
3) **What are the baseline values and which are the target values for measuring success at the beginning and at the end of the project?**

The columns which had to be developed and considered to accomplish the KPI discussion are some already given by previous projects, to assure comparability, some by the data model, to assure later integration and several descriptions which have been previously set already in the proposal and in the Grant Agreement (GA) of ULTIMO. They are listed below:

- KPI number
- Priority (High/Medium/Low)
- Multidimensionality (Social, Economic, Environmental, Technical/Performance, Governance)
- GA or Non-GA
- KPI
- Description
- Calculation Method
- Comments and Guidelines
- Example
- Excerpts from Proposal
- Baseline
- Target value
- Comments from Partners
- Partner to check KPI

The outcome of the questions and discussions are summarized in an Excel file containing the ULTIMO KPIs with guidelines which was made available by ArgYou to every project partner, to the Executive Board and the reviewers and agreed upon in the ULTIMO-team.

2.1 History of KPI Development

The process of KPI development was led by ArgYou in connection with task **7.4 Impact and KPI assessment**, including consultation with previous Horizon 2020 and Horizon Europe projects and collaboration with all ULTIMO partners including PTOs. The original ULTIMO project proposal and the KPIs mentioned in the GA have been analysed to extract all relevant outcomes and impacts. KPIs from previous projects in the same field were collected and gathered together; in total 151 KPIs. In workshops, at the General meeting in Frankfurt and in many bilateral meetings with partners, the final and commonly agreed upon comprehensive KPI list was developed which contains in total 69 KPIs ensuring coverage for each outcome or impact in the ULTIMO project. The main history of the work is listed below:

Date	Topic
02.02.2023	Meeting with CERTH and SHOW template, align with data model
08.03.2023	Consolidation of Avenue and SHOW KPI's with ULTIMO KPIs, proposal mentions
04.09.2023	First review by Prof. Dimitri Konstantas UniGE
13.09.2023	Review Meeting with Prof. Dimitri Konstantas UniGE and ArgYou
21.09.2023	Second review by Prof. Dimitri Konstantas UniGE
19.10.2023	Working Session "KPI List for Impact Assessment" at the ULTIMO General Meeting in Frankfurt
15.11.2023	Deadline for contributions by working session partners and PTOs
22.12.2023	Deadline for contributions by all ULTIMO partners
19.01.2024	Integration of all updates from ULTIMO partners including PTOs
16.02.2024	Delivered for Executive Board first review and feedbacks
31.03.2024	Deadline for submission: First version of the report on Impact and KPI assessment

Table 2:History of work on ULTIMO KPI list

2.2 Rationale for the Choice of KPIs

KPIs were selected based on their ability to quantifiably measure the project's success in achieving these objectives across the outlined dimensions. The processes involved are:

- **Alignment with Objectives**: Ensuring each KPI directly correlates with at least one of the project's objectives, allowing for clear measurement of progress towards those goals.
- **Comprehensive Coverage**: Including a range of KPIs to cover all dimensions—social, economic, environmental, technical/performance, and governance—ensuring a holistic evaluation of the project's impacts.

- **Quantifiability**: Choosing KPIs that offer clear, measurable indicators of success, enabling accurate tracking and evaluation of outcomes.
- **Stakeholder Involvement**: Engaging with project partners and stakeholders to refine KPIs, ensuring they reflect the needs, expectations, and expertise of all parties involved.
- **Benchmarking and Targets**: Setting baselines and target values for each KPI, derived from the project's ambitious goals and the broader context of AV integration into public transportation and logistics services.

The criteria used for selecting KPIs are on one hand an excerpt of previous projects, the proposal, the GA and most importantly, KPIs are defined and measured by the partners who know best what is possible in their field of expertise.

All criteria have been thoroughly discussed, reviewed and double checked by several independent experts and research institutions to ensure that the KPIs are relevant, measurable, and aligned with ULTIMO project goals.

The sustainable integration of AVs for MaaS public transportation for passengers and LaaS for urban goods transportation are the main project's goals and the comprehensive analysis of KPIs are interconnected and carefully defined and described fully in line with this specific AV ecosystem and its overall outcomes and impacts.

3 ULTIMO Key Objectives, Dimensions and KPIs

The ULTIMO project's key objectives encompass a wide range of ambitious goals aimed at revolutionizing the integration and utilization of Automated Vehicles (AVs) within Public Transportation and Logistics services, targeting a more sustainable, efficient, and inclusive mobility ecosystem.

In line with previous work done in the Horizon2020 project AVENUE, the multidimensional aspect is carried over in ULTIMO. Nemoto et al. in “How to measure the impacts of shared automated electric vehicles on urban mobility” (2021)[1] produce indicators for sustainable mobility assessment of SAEV and map them to 5 dimensions (Social, Economic, Environmental, Technical/Performance, Governance). In ULTIMO, the KPIs are mapped to these 5 dimensions to ensure a holistic assessment.

[1]Nemoto, E. H., Issaoui, R., Korbee, D., Jaroudi, I., & Fournier, G. (2021). How to measure the impacts of shared automated electric vehicles on urban mobility. *Transportation research part D: transport and environment*, *93*, 102766.

The following table maps the dimensions and KPIs to ULTIMO's Key Objectives (KO). The numbering of the KPIs can be used to reference them in the comprehensive KPI list in the appendix.

KO#1 Validate Integrated Shared CCAM Systems and Services	
This objective aims to integrate AVs with public transport, creating an environmentally friendly, seamless intermodal trip experience. It directly impacts social inclusivity by providing citizen-centric services, addresses environmental sustainability through zero-emission vehicles, and touches on governance and technical/performance through the implementation of high-quality services integrated with existing mobility solutions.	
Dimensions	
Social, Environmental, Technical/Performance, Governance	
KPIs	
A8	Proactive alternative itineraries for passengers
A13	Local engagement and acceptance
A22	Number of passengers
B1	Average speed
A27	Scheduling coordination (AV on demand)
A32	Transportation time
A40	Speed of Avs
KO#2 Develop Open Source APIs for Seamless Integration	
Focusing on interoperability and minimal investment for integrating multivendor vehicles and services, this objective contributes to economic viability by promoting scalable business models. It also enhances technical performance through direct integration capabilities and supports governance by setting up standards for interoperable components.	
Dimensions	
Technical/Performance, Economic, Governance	
KPIs	
A9	New shuttle average integration time
C5	AV integration in MaaS
KO#3 Large Scale Multivendor Deployments	
Deploying large-scale, citizen-centric, on-demand services contributes socially by addressing diverse mobility patterns and needs. Economically, it utilizes older technology vehicles efficiently, reducing carbon footprint and supporting environmental goals.	
Dimensions	
Social, Economic, Environmental	
KPIs	
A8	Proactive alternative itineraries for passengers
A13	Local engagement and acceptance
A22	Number of passengers
B1	Average speed
A27	Scheduling coordination (AV on demand)
A32	Transportation time
A40	Speed of Avs
A6	Service hours per day
A7	Reservation services
A14	Modernization of city stations

A15	(Acceptable) detour time
A16	AV dispatch time
C1	High density mapping (RSD)
KO#4 Common and Reusable Model for HD Maps	
Creating a common HD map model reduces costs and enhances the economic viability of deploying AVs, directly impacting technical performance by ensuring vehicles can operate more efficiently across diverse environments.	
Dimensions	
Technical/Performance, Economic	
KPIs	
A26	Predictive model accuracy
A45	AV lifetime
C2	Spare parts guarantee
A10	Predictive maintenance and situation awareness for hardware repair time reduction
A11	Predictive maintenance and situation awareness for software repair time reduction
A21	Seamless full scale operation
KO#5 Automated Passenger Services for Safety and Quality	
Enhancing public transportation service quality through innovative in-vehicle services improves safety, security, and the overall passenger experience, addressing social inclusivity and enhancing technical performance.	
Dimensions	
Social, Technical/Performance	
KPIs	
A3	Special needs and inclusive passenger services
A4	In-vehicle communication services
A5	in-vehicle passenger safety services automated
A28	AI event detection reliability
A29	Passenger satisfaction concerning safety
A35	User satisfaction with AV
A41	on board safety driver
C3	Number of handicapped users of ULTIMO services
C6	Passenger security reaction time
C7	Passenger comfortability levels
A33	Number of accidents
A34	Conflicts-Near miss incidents
KO#6 Develop Open Source APIs for Seamless Integration	
Developing business models that allow AVs to be dynamically chartered addresses economic efficiency, social inclusivity by providing on-demand services, and environmental sustainability by optimizing vehicle use.	
Dimensions	
Economic, Social, Environmental	
KPIs	
A1	Value added services proposed for individuals, retailers, freight transport professionals
A17	Cost competitiveness of services
A18	PTO costs
A23	Logistics service use cases

A24	Dynamic chartering of AV by non-PTO
A36	Night time deliveries
A38	Logistics services provider trust
A39	PTO trust
A46	PTO dynamic chartering
A47	Operating costs of Logistics
A12	Nationwide expansion within Germany
KO#7 Improved Interaction with Road Users and Infrastructure	
Enhancing safety and efficiency through better vehicle and infrastructure interaction directly impacts technical performance, contributes to social safety, and supports environmental objectives by optimizing traffic flow.	
Dimensions	
Technical/Performance, Social, Environmental	
KPIs	
A25	Road maintenance costs
A30	Frauds and vandalisms
A44	Cyber-attack impact
A10	Predictive maintenance and situation awareness for hardware repair time reduction
A11	Predictive maintenance and situation awareness for software repair time reduction
A21	Seamless full scale operation
A33	Number of accidents
A34	Conflicts-Near miss incidents
KO#8 Realistic Long-term Transition Planning	
Focusing on a comprehensive assessment of technical, social, economic, and environmental impacts facilitates the creation of sustainable transport systems, directly influencing governance strategies and policies for AV deployment.	
Dimensions	
Governance, Social, Economic, Environmental	
KPIs	
A19	Know-how exchange
A20	Brochure downloads
A31	User acceptance
A37	Passenger trust
A42	Scientific publications
A43	Conference presentations
B2	Website
B3	News feeds
B4	Leaflet publications
B5	e-newsletter
B6	Social media posts
B7	Videos
B8	Attending events
B9	Event organisation
B10	press releases
B11	Citizen co-creation
A48	Energy use

A49	Climate change
A50	Air pollution
C4	Results availability

Table 3: Mapping of ULTIMO Key Objectives to dimensions and KPIs

4 Impact-First Approach

All measures are designed to be entirely passenger, citizen and user-centric. It is expected that passenger and transport industry adoption of the new transportation models will be achieved based on the long-lasting experiences of the project partners, relying on new multi-national, multi-channel user-centric impact measurements, showing what users want and what they actively search for already. This assures the highest technical and societal impacts from the very beginning of the project, during the project lifetime and even long after its completion. The project encompasses different aspects: data-based, individual, sociological, capacity building, technological mobility platforms and awareness. Therefore, the verification of the achievement of the planned objectives will be performed with different modalities and various KPIs.

Digital impact KPIs of the proactive measuring and analysis approach include as principal steps:

1. Gathering ideas on small autonomous busses, mobility and agile transportation as the basic scope: collecting and extracting existing topics, principal ideas and contents of operators and "demonstrators", topics out of trials, workshops, communications, questionnaires, etc.

2. Matching the gathered data (blue bars in Figure 2) with aggregated active search patterns by API on multiple online channels full scale and country specific (red bars in the figure below).

3. Measuring digital impact KPIs: benchmarking the resulting data by measuring the related digital impact to assure social resilience and targeted actions.

Such digital impact KPIs are generated from the latest big data science tools by collecting, aggregating, validating already existing publicly available information on the internet entirely in line with GDPR. This approach is followed in all the works and discussions for all the actors involved, communications, websites (Progressive Web Applications PWA), and workshops. Therefore, the approach of measuring potential "digital impact first", even before determining and analysing the communication measures and briefings, will be undertaken. This stepwise pathway to impact process and approach is considered very important, effective and efficient for supporting this multidisciplinary project's overall goals. Following this strategy, all the project partners will be enabled to use valid and reliable data and contents, available for ongoing and final assessments and evaluations of their contribution to the impact and to the expected outcome.

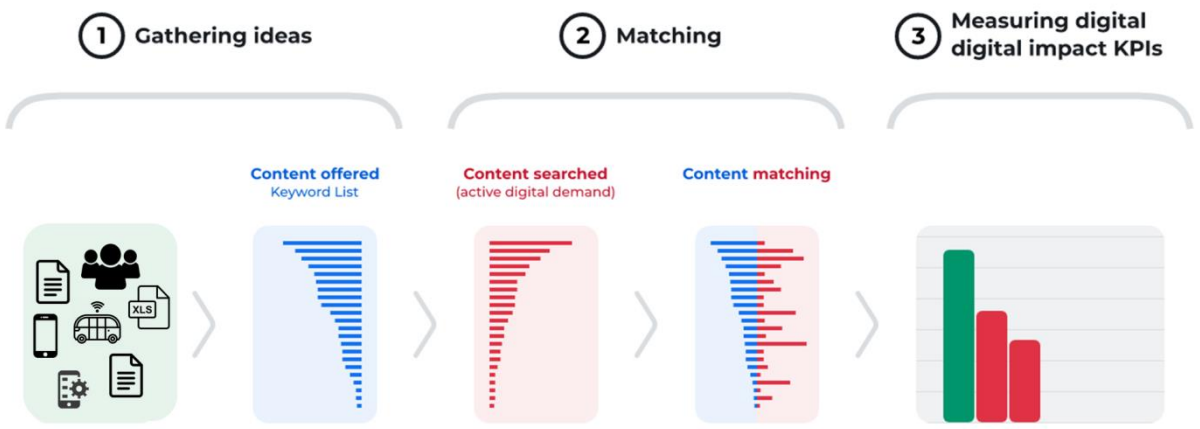

Figure 1: Matching content offered with digital demand

In ULTIMO, many different KPIs are defined at the beginning of the project. Some have been defined in the proposal and some of the KPIs are mirrored from the AVENUE and SHOW projects, to enable comparative evaluations. Other KPIs are defined by the partners and the pilots. All KPIs will be assessed towards the end of the project, some of them already at mid-term review, wherever possible. All partners are dedicated to develop impact on technological, societal, scientific and public (media) levels.
Information generated in the context of ULTIMO is tested regularly for digital impact on all the relevant channels which are most frequently used by the AV community.
Each ULTIMO deployment site is supported systematically to achieve its most possible local, regional and national impact in each of the countries involved and in their national/regional language when showing the AVs fully in operation. The partners will proactively promote the pilot presentations and the new vehicles also in all other countries.

5 Digital Impact and Communication

The focus on digital impact lies on technically measuring the search volume and engagement related to the project's topics to all the communication measures, website, App, media releases, video contents, brochures and evenly the contents which will be relevant to the pilots, the sites in the respective languages and on the national digital channels. The technical approach focuses in an innovative way on one hand on the optimization of the published contents **(speech)** towards more impact on the user side for visibility and readability as well as “findability” on all search platforms. Furthermore it measures, even more important, for impact also on the **used and understood or searched** aspects of the published contents **(reach)** directly by the **users**. All communication plans and measures where applicable and where the partners deliver their dedicated contents and keyword setup, ULTIMO follows an impact assessment and is analysing preliminary base line data and ongoing monitoring data from the active users and is providing those results **immediately and directly** to the communicators and professionals who are involved in all ULTIOMO communication and dissemination **actions**. The data is used by the C&D Team from UITP, the advertising agencies responsible for web and video etc.. In the pilot context, as soon as the pilots start, the PTOs and their own communication activities will also be accompanied and

assessed proactively by the impact assessment partner ArgYou with national data for the pilot country.

5.1 Digital Impact Monitoring Strategy

The “impact first” strategy analyses proactively all contents generated and delivers the impact KPIs for the teams working on the contents, on the use cases and on the pilot sites, with the aim of having the strongest possible positive impact on the users, passengers, transportation as well as on the AV community and on all the stakeholders. On the digital channels, like search engines, social media and e-platforms a project name monitoring is measuring the online impact of ULTIMO by researching important specific keywords names and brands and their communication KPIs during the four years period of the project. The ULTIMO digital keyword monitoring strategy starts with the creation of a project keyword list in collaboration with all the partners of ULTIMO, refined by the communication team. The result is a comprehensive list of keywords and a short list of branding keywords for ULTIMO. The branding keywords are monitored monthly over the project’s lifetime to see whether the ULTIMO brand is taken up in their search queries by the users on the internet. The comprehensive list of keywords is measured at the start, in the middle and at the end of the project, in order to have a reference search volume for these keywords at different stages of the project. As for the pilots’ keyword monitoring, up until the start of the pilots, more specific keyword lists are developed in collaboration with the pilot partners. These lists are then monitored monthly, in the same vein as the branding keywords.

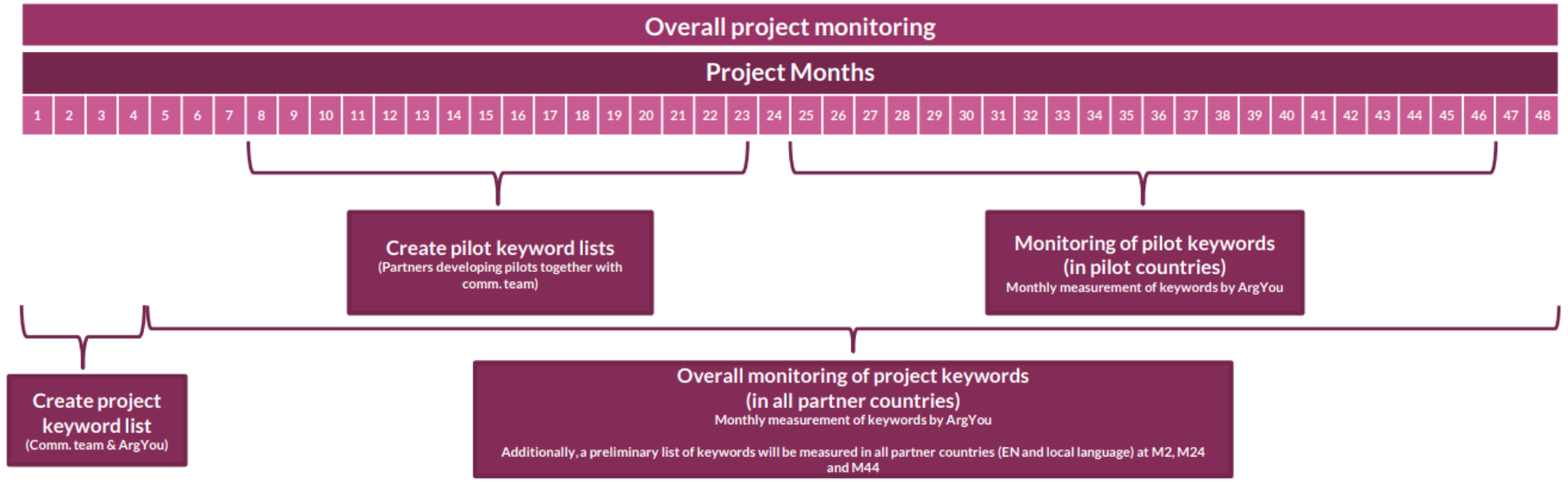

Figure 2: Visualisation of the overall project keyword user-demand monitoring strategy

5.2 Digital Impact Monitoring Preliminary Results

The “impact first” results of the first monitoring period are the base-line measurements for analysing the user-demand for the predefined keywords in the ULTIMO project. It shows the different average user search volumes in the different partner countries for the keyword “horizon Europe ULTIMO” and for “ULTIMO partners”. These results are followed by the keyword setup in Germany, Norway and Switzerland, where the pilots will take place. It can be noticed that in Germany, the search volume for “Autonomous driving Busses” is comparatively low, as it is more or less on the level as in Switzerland and Norway. An explanation could be that Germans are using more German terms instead of English ones when looking for autonomous driving busses, but this is not substantiated yet. All trends are already positive for the topic which has been selected as a range of project related keywords, even though the pilots have not yet been started except for some pre-tests in Oslo.

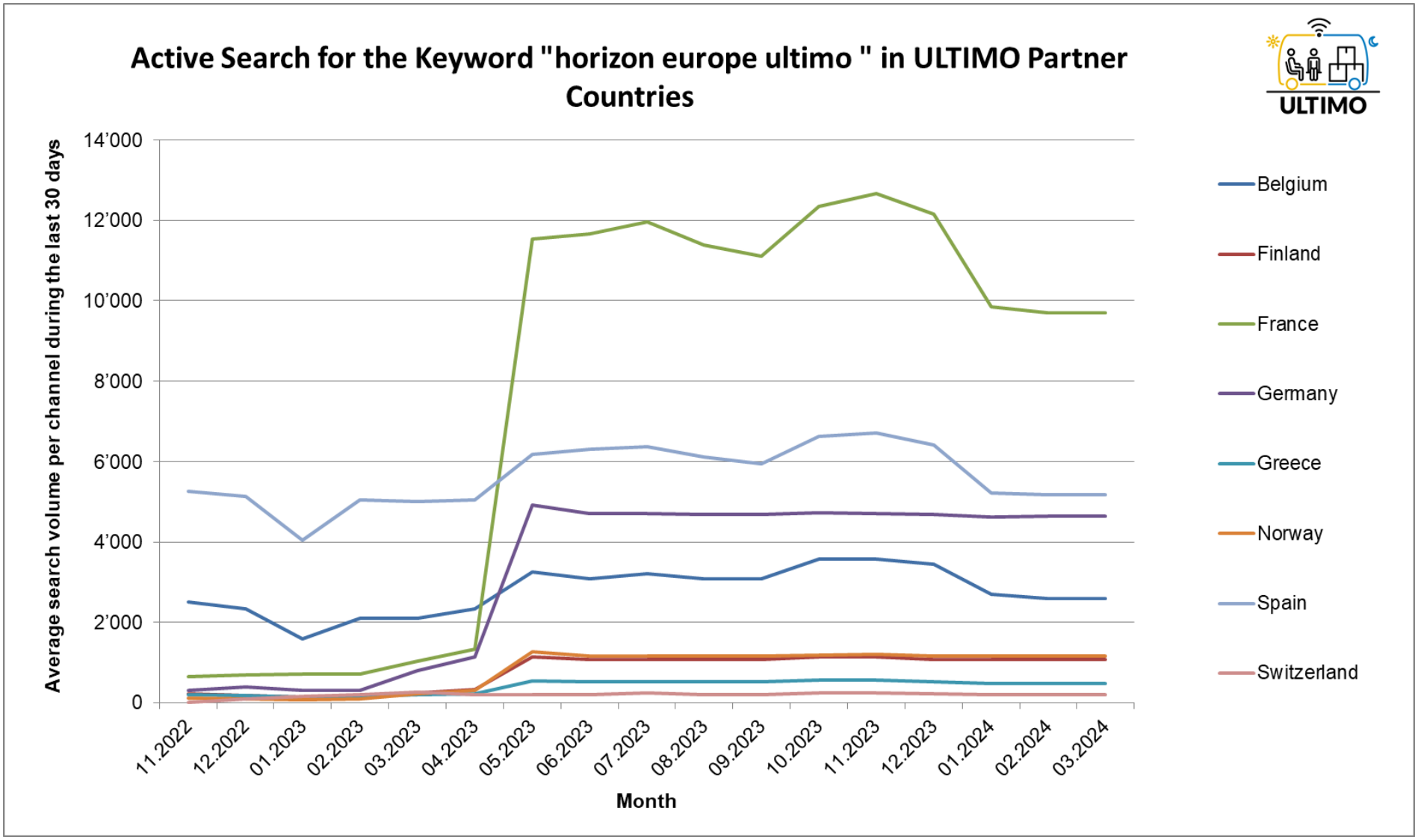

Figure 3: Average search volume per channel per month in the countries of the project partners for the keyword "horizon europe ultimo".

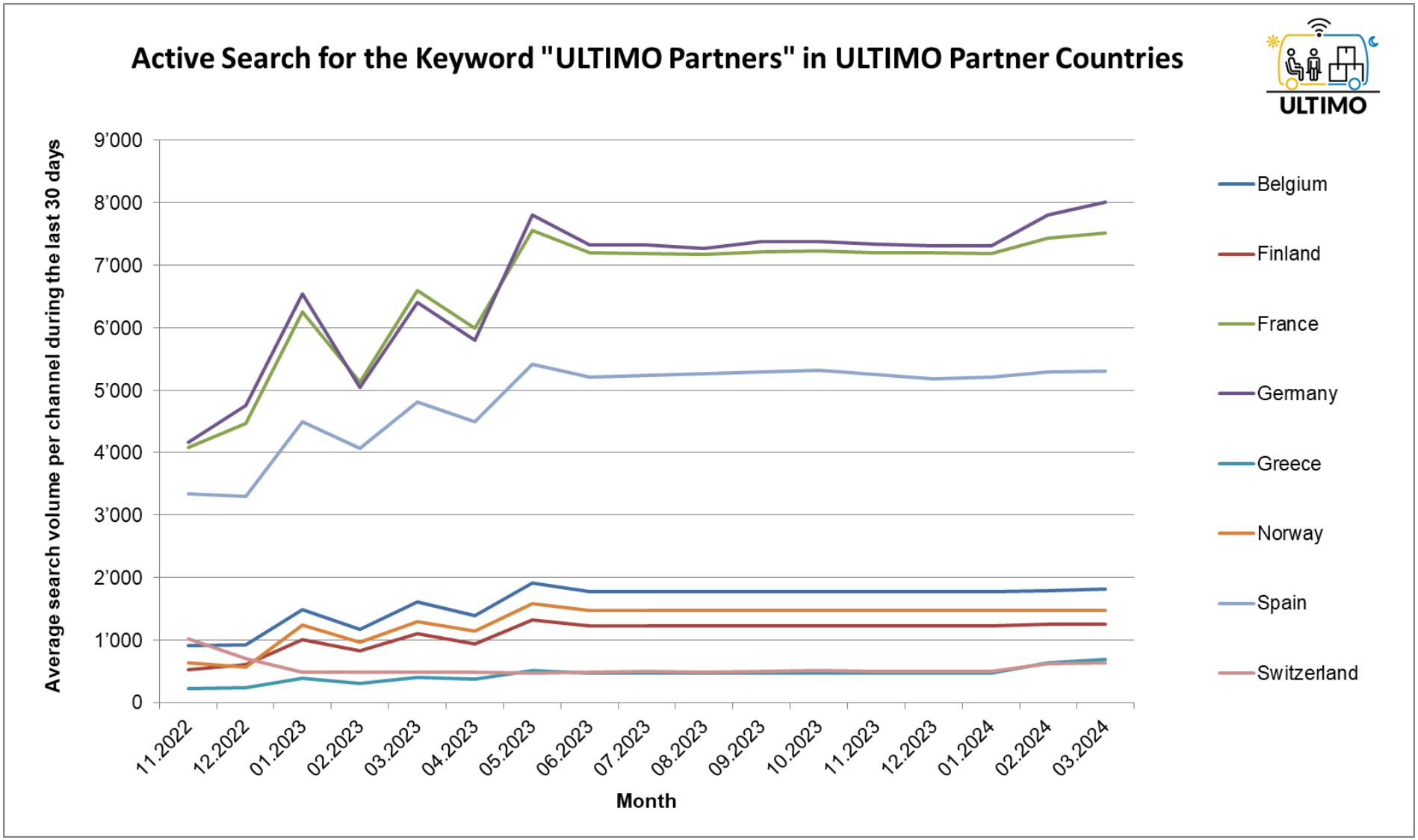

Figure 4: Average search volume per channel per month in the countries of the project partners for the keyword "ULTIMO Partners".

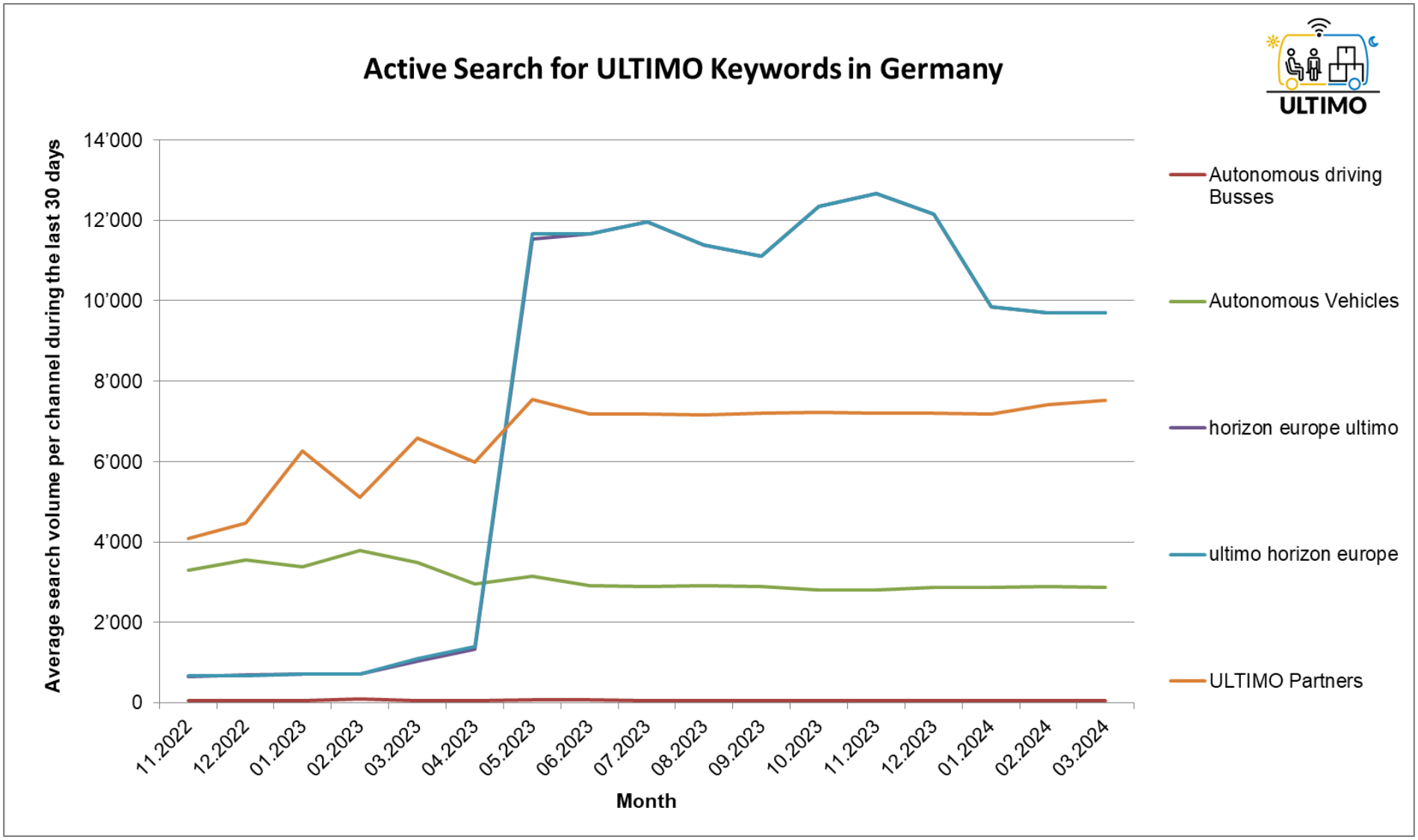

Figure 5: Average search volume per channel per month in Germany for the keywords "Autonomous driving Busses", "Autonomous Vehicles", "horizon europe ultimo", "ultimo horizon europe" and "ULTIMO Partners".

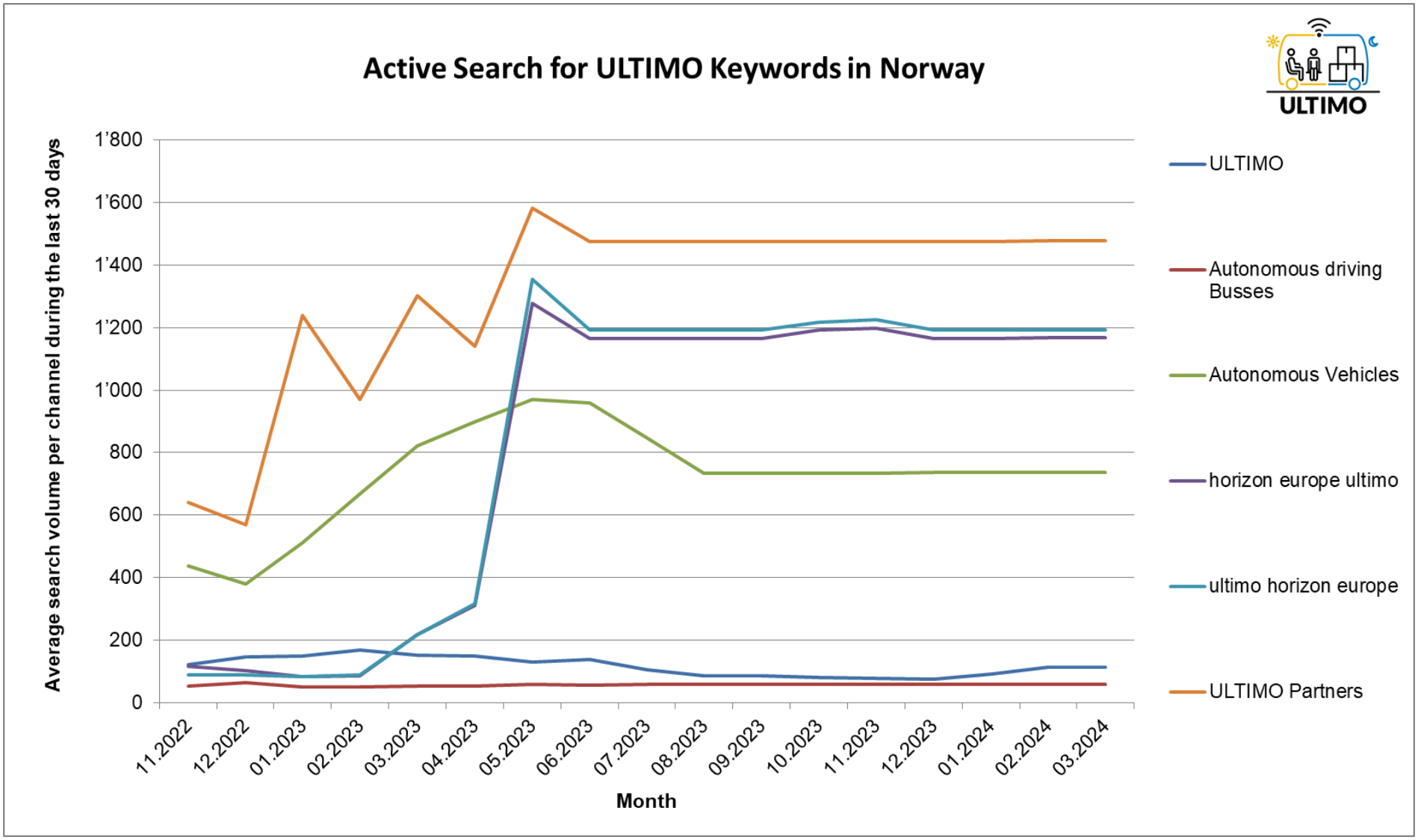

Figure 6: Average search volume per channel per month in Norway for the keywords "Autonomous driving Busses", "Autonomous Vehicles", "horizon europe ultimo", "ultimo horizon europe" and "ULTIMO Partners".

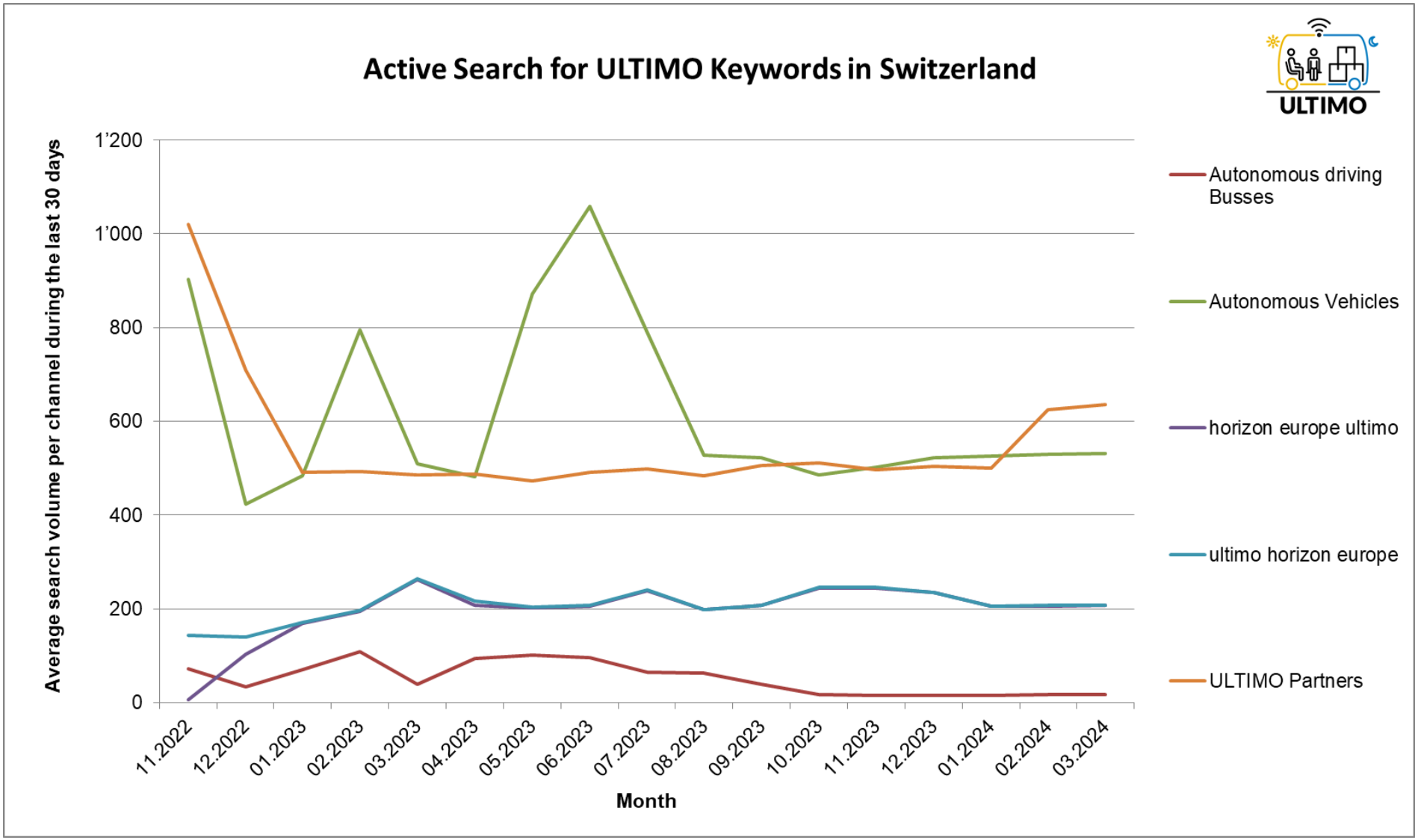

Figure 7: Average search volume per channel per month in Switzerland for the keywords "Autonomous driving Busses", "Autonomous Vehicles", "horizon europe ultimo", "ultimo horizon europe" and "ULTIMO Partners".

6 Outcomes, Impacts and KPIs

ULTIMO has set out to achieve various outcomes and impacts. This chapter maps the KPIs to the social, economic, environmental, technical/performance, and governance outcomes and shows the progress made on the ambitious targets. However, as only in Oslo first pilots are up and running at this stage of the project there is no data available yet. Thus, this first version of the report on impact and KPI assessment concentrates on setting up the framework with baselines and target values and the final version of the report will incorporate the comprehensive assessment of ULTIMO's impact and KPIs.

The following table provides an overview on the multidimensional outcomes and impacts sought by ULTIMO, while in the subsequent chapters the target KPIs for the respective dimensions including descriptions baselines and target values will be indicated. As many KPIs are multidimensional, there will be multiple mentions of KPIs. This means that if, for example, a KPI is mapped to the social and economic dimension, it will be mentioned in chapters 6.1 and 6.2. The baselines were defined mainly using the AVENUE, and SHOW projects as sources, because only AVENUE[2] and SHOW[3] were able to collect real data from passengers, users and service operation from real, concrete and regular public AV based, on-demand transportation services, based on objective tangible information of real service deployments. This way the opinions and data collected represent the real issues and are based on real and measurable information regarding vehicle operation, costs, user experience etc. As a result, AVENUE and SHOW represent the SoA in the evaluation of public transportation performance, costs and passenger feedback, as they are the only real long term deployments of AVs in Europe.

[2] https://h2020-avenue.eu/public-delivrables/
[3] https://show-project.eu/media/deliverables/

Dimension	ULTIMO Outcome / Impact
Social	Optimisation of transportation times
	Reduction of the Nr of accidents[4]
	Increased overall user satisfaction and acceptance of the AVs in MaaS and LaaS services
	Increased trust of passengers/PTOs/Logistics service providers
	Share effectively the knowledge generated under ULTIMO
	Eliminating incompatibilities and inconsistencies in data transition, increasing the safety for passengers and road users, and also overcoming the problem of the customer "lock-in"
	Estimated reduction of human borne errors (e.g. limit/signal violations)
	Increased safety and efficiency in transport flows
	Improvement of QoL by reducing time needed
	Creation of new jobs opportunities; Reduction of unemployment rate
	Reduction of the healthcare cost for the serious injured people from car accidents
Economic	PT and Logistics sectors directly beneficiated from ULTIMO solutions by the end of the project (e.g. by low operating costs)
	Increase the night-time deliveries (silent unloading) in the studied cities, by the end of the project (this will increase parking availability in town centres, reduce traffic, improve mobility, etc.)
	Introduce economic viable cases for passengers and goods
	New cross-sector business models
	Create more standardised and integrated financial schemes and novel Business models for MaaS and LaaS services across Europe
	Increase the use of dynamic chartering of AVs by non-PTO service providers by around 2-4% in the studied cities, by the end of the project
	Reduce operational costs for Logistic services (dynamic charting instead of buying an AV, reduced fuels, don't need a driver, etc.)
	Increased income for the PTOs by the dynamic chartering of the AVs and the partnerships created
	Financial benefits due to safer and more efficient transportation of goods
	Financial benefits from reducing fuel consumption as well as road maintenance costs
	Reduction of GHG emissions due to the implementation of ULTIMO solutions compared to existing conventional alternatives

[4] Based on the current figures for transport accidents adapted to the deployment sites.
Switzerland: Swiss Federal Statistics Office, "Transport accidents - overview of all transport modes", https://www.bfs.admin.ch/bfs/en/home/statistics/mobility-transport/accidents-environmental-impact/transport-accidents.assetdetail.18064666.html

Environmental	Reduced of emissions and noise pollution by replacing traditional busses with electrical AVs and reducing the use of private cars and trucks
	Reduction of GHG emissions due to the implementation of ULTIMO solutions compared to existing conventional alternatives
Technical/Performance	High use of the scientific discovery published (measured with the relative rate of citation index of project publications), on issues relevant to multi-vendor and multi-purpose automated transportation systems, etc.
	Reach scientific community
	Percentage of AVs travelling within the speed limit increased
	High quality performance requirements for environment perception systems with respect to different automation levels and ODDs
	Improved resolution for real time driving decision making
	Fostering diffusion of knowledge and creation of synergies in EU towards promotion of AV-based CCAM for MaaS&LaaS services
	Support the development of large-scale system deployments by 2027 and beyond
	Increased security in users interaction and data exchange
	New and innovative components and technologies in CCAM field for L4 operating AVs
Governance	Improved innovation capacity
	Cooperation with other EU activities
	Introduce a holistic sustainable solution at high TRL level, in order for the post-project mass replication and market uptake
	Create more standardised and integrated financial schemes and novel BMs for the PT transformation in the EU
	Introduce to market a new, tested and validated AV-based CCAM transportation system that work for people, improving competitiveness
	Robust continuity at market shares
	New collaborations with EU activities

Table 4: ULTIMO Outcomes and Impacts mapped to dimensions

6.1 Social KPIs

#	KPI	Description	Baseline	Target value
A1	Value added services proposed for individuals, retailers, freight transport professionals	Number of value added services proposed for individuals, retailers, freight transport professionals	0	8
A3	Special needs and inclusive passenger services	Classification of types of impairments that are supported to use the ULTIMO service	0	9 "9" will only be realisable for some user groups with a suitable assistance service
A4	In-vehicle communication services	Number of in-vehicle communication services	minimum 1	>=1
A5	In-vehicle passenger safety services automated	Number of in-vehicle passenger safety incident types that can be handled automatically	4	4
A7	Reservation services	Number of reservations per day in reservation services for shuttles	0	Ruter: 450 per day TPG: 350 per day DB: 250 per day
A8	Proactive alternative itineraries for passengers	Number of proactive alternative itineraries proposed to passengers	0	1
A13	Local engagement and acceptance	Number of recurring (>5-times) users per service per site	0	Ruter: 500 TPG: 400 DB: 450
A14	Modernization of city stations	Number and density of flexible virtual pick-up and drop-off locations per site	0	Ruter: 150 PUDOS, and <2 minutes to walk

#	KPI	Description	Baseline	Target value
				TPG: not envisaged DB: 75
A15	(acceptable) Detour time	Detour time per ride	n/a	Optimal ETE/ETA + 10 minutes
A17	Cost competitiveness of services	Cost of ULTIMO services and comparable other services Price for a ticket (passenger) for a certain ride Price for a freight delivery (unit cost)	Current prices for PT	Ruter: Max 2x current ticket price TPG: current ticket prices DB: current ticket prices
A19	Know-how exchange	Number of projects / EU initiatives with know-how exchanges	0	>=5
A20	Brochure downloads	Number of downloads of the technical brochure posted on the ULTIMO website	0	>75
A22	Number of passengers	Number of people transported throughout the project per automated vehicle/service type	0	50000
A29	Passenger satisfaction concerning safety	Average passenger satisfaction concerning safety	1. It is not clear how autonomous e-minibuses react in unforeseen situations : 54% agreement 2. I would not feel secure in an automated minibus in case of harassment and assault : 43% agreement 3. The technology is not yet ready to drive on public roads : 31% agreement	>70% increase
A30	Vandalisms	Number of incidents involving vandalism	0	<5

#	KPI	Description	Baseline	Target value
A31	User acceptance	User acceptance rate of ULTIMO solutions	1. transports made with public transportation 13 - 17% (depending on region : urban, rural) – (whereas private 38% and soft mobility 54%) 2. Average daily distance : total 25km, public transport 3.8 to 7.8 km (15-30%) (depending region : rural to urban) 3. Urban logistics night time delivery : 85% user acceptance for night reception (in distribution box)	>=20% increase
A33	Number of accidents	Number of accidents in ULTIMO	0	0
A34	Conflicts-Near miss incidents	Total number of conflicts-near miss incidents. A conflict is a critical traffic situation in which the intervention of the safety driver modifies vehicle`s trajectory or behaviour preventing an accident with other vehicle or person or an extremely uncomfortable situations within the vehicle. The total number of conflicts-near miss incidents is recorded through the driver safety report.	25 conflicts /1000 km	10-20% reduction
A35	User satisfaction with AV	Average of user satisfaction	n/a	>90%
A36	Night time deliveries	Number of night-time (until 23:00) deliveries in deployment cities	0	>1

#	KPI	Description	Baseline	Target value
A37	Passenger trust	Average user trust in ULTIMO solution	1. Willingness to use AVs : Overall 63% acceptance and trust to use AVs. 2. Willingness to reduce use of private car (if it offers on-demand service) : 58% 3. Willingness to pay to use AVs (if it offers on-demand services) : 36%	>90%
A38	Logistics services provider trust	Average logistics services provider trust in ULTIMO solution	1. Willingness to use AVs : Overall 63% acceptance and trust to use AVs. 2. Willingness to reduce use of private car (if it offers on-demand service) : 58% 3. Willingness to pay to use AVs (if it offers on-demand services) : 36%	>90%
A39	PTO trust	Average PTO trust in ULTIMO solution	1. Willingness to use AVs : Overall 63% acceptance and trust to use AVs. 2. Willingness to reduce use of private car (if it offers on-demand service) : 58% 3. Willingness to pay to use AVs (if it offers on-demand services) : 36%	>90%
A41	On board safety driver	Rides/vehicles without an on-board safety driver	0	1

#	KPI	Description	Baseline	Target value
A42	Scientific publications	Number of papers submitted to peer-reviewed scientific publications	0	>=15
A43	Conference presentations	Number of presentations held at conferences	0	>15

B2	Website	Number of website visits	0	1st year 500, 2nd year 1000, 3rd year 2000, 4th year 2500
B3	News feeds	Number of articles/news on project's and partners' websites	0	1st year 10, 2nd year 15, 3rd year 20, 4th year 25
B4	Leaflet publications	Number of project leaflets created Number of project leaflets distributed	0	1st year 1 produced, 500 distributed 2nd year 0 produced, 1000 distributed 3rd year 1 produced, 500 distributed 4th year 1 produced, 1000 Distributed
B5	E-newsletter	Number of newsletters sent out Number of newsletter subscribers	0	1st year 1 sent, 60 subscribed 2nd year 2 sent, 100 subscribed 3rd year 2 sent, 150 subscribed 4th year 2 sent, 300 subscribed

#	KPI	Description	Baseline	Target value
B6	Social media posts	Number of social media posts	0	1st year 4/month, 2nd year 5/month, 3rd year 8/month, 4th year 10/month,
B7	Videos	Number of videos created	0	1st year 1, 2nd year 0, 3rd year 1-3, 4th year 1
B8	Attending events	Number of events attended by ULTIMO consortium partners	0	1st year 6, 2nd year 15, 3rd year 25, 4th year 20
B9	Event organisation	Number of events organised by ULTIMO consortium partners	0	Y1: 4 Y2: 6 Y3: 6 Y4: 8
B10	Press releases	Number of press releases	0	Y1 > 2 Y2 > 1 Y3 > 3 Y4 > 4
B11	Citizen co-creation	Number of participants for co-creation events	0	25 per site and event

C3	Acceptance by handicapped people	Number of handicapped users of ULTIMO solutions	0	25

#	KPI	Description	Baseline	Target value
C4	Results availability	Number of languages the ULTIMO results are translated in	0	4
C5	AV integration in MaaS	Level of integration of the new AV into a MaaS network	0 or 1, depending on test site[5]	3 or 4
C6	Passenger security reaction time	Average time it takes for help to arrive in case of harassment or assault	0	<5 min[6]
C7	Passenger comfortability levels	The passenger comfortability is based on the analysis of vehicle's performance data. The GPS data for speed is manipulated in order the acceleration value to be calculated, in the case that the specific sensor is not available. Based on the absolute acceleration values the following classes as percentages are calculated: Comfortable, Little Uncomfortable, Fairly Uncomfortable, Uncomfortable, Very Uncomfortable, Extremely Uncomfortable and Hard breaking event. This method has been defined and verified in terms of SHOW[7] project	Hard breaking events: 0.015%. The sum of the ranges from Uncomfortable until the extremely uncomfortable 0.5% of the total acceleration values	Hard breaking events: 0.005%. The sum of the ranges from Uncomfortable until the extremely uncomfortable less than 0.01% of the total acceleration values

Table 5: Social KPIs of ULTIMO

[5] evaluation based on typology of Socher et al. (2018) https://doi.org/10.1016/j.rtbm.2018.12.003
Level 0: no integration single, separate services)
Level 1: Integration of information (multimodal travel planner, price info)
Level 2: Integration of booking & payment (single trip - find, book and pay)
Level 3: Integration of the service offer (bundling/subscription, contracts etc.)
Level 4: Integration of societal goals (policies, incentives etc.)
[6] This depends on the local policies and laws.
[7] https://show-project.eu/

6.2 Economic KPIs

#	KPI	Description	Baseline	Target value
A1	Value added services proposed for individuals, retailers, freight transport professionals	Number of value added services proposed for individuals, retailers, freight transport professionals	0	8
A2	Number of cargo units transported	Number of cargo units transported throughout the project and interest	0	150 300
A8	Proactive alternative itineraries for passengers	Number of proactive alternative itineraries proposed to passengers	0	1
A9	new shuttle average integration time	average time to integrate a new type vehicle into the current fleet, once it has the standard API	1 to 2 month	10 days
A10	predictive maintenance and situation awareness for hardware repair time reduction	average time it takes to repair hardware components	2 months	1 week
A11	predictive maintenance and situation awareness for software repair time reduction	average time it takes to resolve software issues	2-3 months	1 week
A16	AV dispatch time	time between booking and vehicle arrival	30 min	Ruter: 15 min TPG: 30 min DB: 30 min
A17	Cost competitiveness of services	Cost of ULTIMO services and comparable other services Price for a ticket (passenger) for a certain ride Price for a freight delivery (unit cost)	Current prices for PT	Ruter: Max 2x current ticket price TPG: current ticket prices DB: current ticket prices
A18	PTO costs	Cost for the PTO per passenger per trip Cost for public transport for the	Costs: based on the Geneva “traditional” public	>30% reduction of cost

#	KPI	Description	Baseline	Target value
		passenger per Km Cost of driver in public transportation % of total operation cost of a bus Cost per passenger per km Cost per shuttle per km	transportation 1. Cost for the PTO per passenger per trip : 1.98 CHF (where 1.20 CHF is public subvention) 2. Cost for public transport for the passenger: 0.22 CHF per passenger per Km 3. Cost of driver in public transportation: 40 to 64% of total operation cost of a bus Costs of AV deployment: based on AVENUE evaluation D8.6 1. Cost per passenger per km : average of 0.99 EUR 2. Cost per shuttle per km : average 14.86 EUR	
A21	Seamless full scale operation	number of days of outages of operation of the ULTIMO solution	n/a	>70%
A22	Number of passengers	Number of people transported throughout the project per automated vehicle/service type	0	50000
A23	Logistics service use cases	number of use cases for logistics services implemented	0	1 services 2 usecases
A24	Dynamic chartering of AV by non-PTO	number of dynamic charterings of AVs by non-PTO service providers	0	>1
A25	Road maintenance costs	average cost for road maintenance in deployment sites	0	0
A30	Vandalisms	number of incidents involving vandalism	0	<5

#	KPI	Description	Baseline	Target value
A45	AV lifetime	average projected lifetime of AVs in the deployment site fleets	6 years	12-15 years
A46	PTO dynamic chartering	income through dynamic chartering of AVs	n/a	n/a
A47	Operating costs of Logistics	operating costs for logistics services (only AV)	n/a	n/a

Table 6: Economic KPIs of ULTIMO

6.3 Environmental KPIs

#	KPI	Description	Baseline	Target value
A1	Value added services proposed for individuals, retailers, freight transport professionals	Number of value added services proposed for individuals, retailers, freight transport professionals	0	8
A2	Number of cargo units transported	Number of cargo units transported throughout the project and interest	0	150 300
A36	Night time deliveries	Number of night-time deliveries in deployment cities	0	>1
A45	AV lifetime	Average projected lifetime of AVs in the deployment site fleets	6 years	12-15 years
A48	Energy use	Energy use per kilometre of a vehicle (g/km, J/km, or kWh/km)	0.985 kWh/km	reduction
A49	Climate change	GHG emissions	CO2eq emissions of status quo (current situation)	reduction
A50	Air pollution	Emissions of air pollutants, PM levels, Nox, CO emissions	Emissions of status quo (current situation)	reduction

C2	Spare parts guarantee	Time horizon in which the delivery of spare parts is guaranteed	10	15-30 years

Table 7: Environmental KPIs of ULTIMO

6.4 Technical/Performance KPIs

#	KPI	Description	Baseline	Target value
A1	Value added services proposed for individuals, retailers, freight transport professionals	Number of value added services proposed for individuals, retailers, freight transport professionals	0	8
A4	In-vehicle communication services	Number of in-vehicle communication services	minimum 1	>=1
A5	In-vehicle passenger safety services automated	Number of in-vehicle passenger safety incident types that can be handled automatically	4	4
A6	Service hours per day	Number of passenger transport service hours per day	1 day per week	24h per day
A7	Reservation services	Number of reservations per day in reservation services for shuttles	0	Ruter: 450 per day TPG: 350 per day DB: 250 per day
A8	Proactive alternative itineraries for passengers	Number of proactive alternative itineraries proposed to passengers	0	1
A9	New shuttle average integration time	Average time to integrate a new type vehicle into the current fleet, once it has the standard API	1 to 2 month	10 days
A10	Predictive maintenance and situation awareness for hardware repair time reduction	Average time it takes to repair hardware components	2 months	1 week
A11	Predictive maintenance and situation awareness for software repair time reduction	Average time it takes to resolve software issues	2-3 months	1 week
A14	Modernization of city stations	Number and density of flexible virtual pick-up and drop-off locations per site	0	Ruter: 150 PUDOS, and <2 minutes to walk

#	KPI	Description	Baseline	Target value
				TPG: not envisaged DB: 75
A15	(acceptable) Detour time	Detour time per ride	n/a	Optimal ETE/ETA + 10 minutes
A16	AV dispatch time	Time between booking and vehicle arrival	30 min	Ruter: 15 min TPG: 30 min DB: 30 min
A17	Cost competitiveness of services	Cost of ULTIMO services and comparable other services Price for a ticket (passenger) for a certain ride Price for a freight delivery (unit cost)	Current prices for PT	Ruter: Max 2x current ticket price TPG: current ticket prices DB: current ticket prices
A21	Seamless full scale operation	Number of days of outages of operation of the ULTIMO solution	n/a	>70%
A22	Number of passengers	Number of people transported throughout the project per automated vehicle/service type	0	50000
A23	Logistics service use cases	Number of use cases for logistics services implemented	0	1 services 2 use cases
A24	dynamic chartering of AV by non-PTO	Number of dynamic charterings of AVs by non-PTO service providers	0	>1
A25	Road maintenance costs	Average cost for road maintenance in deployment sites	0	0
A26	Predictive model accuracy	Estimated accuracy of predictive model	0.75	>85%
A27	Scheduling coordination (AV on demand)	Delay time of AVs	0	>5% improvement
A28	AI event detection reliability	Percentage of reliability of AI for event detection compared to human classification (baseline data)	0.75	>85%

#	KPI	Description	Baseline	Target value
A32	Transportation time	Average transportation time in ULTIMO relative to average transportation time before ULTIMO	0	15% reduction
A33	Number of accidents	Number of accidents in ULTIMO	0	0
A34	Conflicts-Near miss incidents	Total number of conflicts-near miss incidents. A conflict is a critical traffic situation in which the intervention of the safety driver modifies vehicle`s trajectory or behaviour preventing an accident with other vehicle or person or an extremely uncomfortable situations within the vehicle. The total number of conflicts-near miss incidents is recorded through the driver safety report.	25 conflicts /1000 km	10-20% reduction
A40	Top speed of AVs	Top speed reached by fastest AV deployed	20-25 km/h	DB: 60 km/h Oslo: 80 km/h TPG: 90 km/h
A44	Cyber-attack impact	Number of cyber-attacks and hours of downtime due to cyber attacks	n/a	0
A45	AV lifetime	average projected lifetime of AVs in the deployment site fleets	6 years	12-15 years
B1	Average speed	Average speed of pilot vehicles in cities	Ruter: 22 km/h Average travel speed (with traditional public transport means) : 9.4km/h	Ruter: 22 km/h Same es current fleets of driver based busses = 18 to 20 km/h
C1	High density mapping (RSD)	RSD coverage in pilot network	0	94.6% (Ruter) 100% of the route that is driven (Gama)
C2	Spare parts guarantee	Time horizon in which the delivery of spare parts is	10	15-30 years

#	KPI	Description	Baseline	Target value
		guaranteed		
C4	Results availability	Number of languages the ULTIMO results are translated in	0	4
C5	AV integration in MaaS	Level of integration of the new AV into a MaaS network	0 or 1, depending on test site	3 or 4
C7	Passenger comfortability levels	The passenger comfortability is based on the analysis of vehicle's performance data. The GPS data for speed is manipulated in order the acceleration value to be calculated, in the case that the specific sensor is not available. Based on the absolute acceleration values the following classes as percentages are calculated: Comfortable, Little Uncomfortable, Fairly Uncomfortable, Uncomfortable, Very Uncomfortable, Extremely Uncomfortable and Hard breaking event. This method has been defined and verified in terms of SHOW[8] project	Hard breaking events: 0.015%. The sum of the ranges from Uncomfortable until the extremely uncomfortable 0.5% of the total acceleration values	Hard breaking events: 0.005%. The sum of the ranges from Uncomfortable until the extremely uncomfortable less than 0.01% of the total acceleration values

Table 8: Technical/Performance KPIs of ULTIMO

[8] https://show-project.eu/

6.5 Governance KPIs

#	KPI	Description	Baseline	Target value
A12	Nationwide expansion within Germany	Number of PTOs using AVs in Germany	25 (Level 2-3)	10 PTA/PTO's in Germany
A14	Modernization of city stations	Number and density of flexible virtual pick-up and drop-off locations per site	0	Ruter: 150 PUDOS, and <2 minutes to walk TPG: not envisaged DB: 75
A25	Road maintenance costs	average cost for road maintenance in deployment sites	0	n/a[9]
A26	Predictive model accuracy	estimated accuracy of predictive model	0.75	>85%
A41	on board safety driver	rides/vehicles without an on-board safety driver	0	1
C5	AV integration in MaaS	level of integration of the new AV into a MaaS network	0 or 1, depending on test site[10]	3 or 4

Table 9: Governance KPIs of ULTIMO

[9] The estimated value will be available in a report from WP6
[10] evaluation based on typology of Socher et al. (2018) https://doi.org/10.1016/j.rtbm.2018.12.003
Level 0: no integration single, separate services)
Level 1: Integration of information (multimodal travel planner, price info)
Level 2: Integration of booking & payment (single trip - find, book and pay)
Level 3: Integration of the service offer (bundling/subscription, contracts etc.)
Level 4: Integration of societal goals (policies, incentives etc.)
[10] This depends on the local policies and laws.

7 Conclusions and Next Steps

KPI assessment is a critical process for each partner, for all work packages and tasks and for ULTIMO project as a whole. The key findings are that it sometimes takes a long to find an agreeable figure/measure. As in innovative projects like ULTIMO there are usually no baseline figures/values available or they are just zero=0, this means defining target values can be particularly challenging and needs extensive discussions. As one simple explanatory case we can describe the KPIs A40 and B1, the average and maximum speed of the future AV shuttles, to illustrate the challenges involved in KPI assessment: The discussion about the speed of an AV went from discussions on rather high **top speed** to discussions on **average speed in cities**. The differences varied between targets for top speed of 20 to 25 km/h (as in early trials) up to a rather ideal (wishful) speed of 60 to 120 km/h for top speed. Also, a discussion on the baseline for average speed in the populated city center varies between 9.4 km/h and 18-20 km/h. The target value for average speed of pilot vehicles in cities is finally set to 22 km/h for Ruter, and to 18-20 km/h for the other sites, corresponding to the **Average speed KPI B1**. Due to considerable differences between the pilot sites for the **Top speed of AVs KPI A40**, target values needed to be fixed per site: **DB: 60km/h; Ruter: 80km/h, and TPG: 90km/h**. For an acceptable service, ULTIMO will need to make sure that the trip made by AVs is not slower than if it would had been made by a driver-based vehicle. Today the maximum speed of driver-based busses is 80 km/h, and the average speed limits in the city can vary from 30 to 50km/h (depending if it is in urban or sub-urban environment). At the same time each site has different requirements: for example, in Oslo, the vehicles would need to go to the highway, so a minimum speed of 60 km/h is compulsory. This is not the case for the other sites, which operate in an urban environment and where the maximum speed does not exceed 70 km/h also largely depending on the local traffic laws and regulations.

The KPIs in ULTIMO for the project and the work done in the project can be assessed **internally** on a solid ground. However, there will be many **external influencing factors**, which are out of reach of the project teams like dynamic environmental, political, legal, technological factors which may have an influence on the KPI result. The final impact and KPI assessment will assess and where not possible describe them in the final report.

KPIs are set and agreed on at the beginning of the process and assessed towards the end of the project. The ranking for example according to the stakeholder benefits (Citizen, PTO, PTA, OEM) or categorization of KPIs within the AV as MaaS and LaaS ecosystem dimensions and comparisons among the existing predefined KPIs is always possible, whereas **the KPI list is frozen and cannot be modified anymore after the deliverable is submitted.** Nevertheless, the list will serve as an accompanying guide throughout the ULTIMO project. For KPIs which cannot be measured and KPI targets which cannot be reached for various internal or external reasons, the influencing factors or causes will be discussed and explained ongoing during the project and will be summarized in the final reports. The KPI assessment team of ArgYou will start in early summer 2026 to collect available KPI measures and report big variations where discovered. They will be integrated in the data model and it will serve as a basis for the overall **evaluation** of the project. **The final impact and KPI assessment report is due end of September 2026**. The final report will explain how each stakeholder group benefits from the project outcomes. It will compare/benchmark outcomes with earlier AV projects and their previous KPI setups.

Annex

Full list of KPIs with descriptions, calculation methods, comments and guidelines, examples, excerpts from proposal, baselines, and target values for reference.

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
A1	High	x	x	x	x		GA	value added services proposed for individuals, retailers, freight transport professionals	Number of value added services proposed for individuals, retailers, freight transport professionals	counting	from reports on newly developed services that are implemented the value proposed can be in the vehicles in vehicle services to address secury and safety issures; Citzen centricity: from the application: is the service integrated in a MaaS; on -demand; integration of LaaS service for the PTO	2 services adressing security 1 service adressing MaaS integration 1 service addressing LaaS	1) Develop value-added services that have a positive impact on quality of life and the environment, and are aimed at three distinct target audiences: a) Individuals b) Retailers c) Freight transport professionals	0	8
A2	Low		x	x			GA	Number of cargo units transported	Number of cargo units transported throughout the project and interest	Number of cargo unit transported Number of attempts to book vehicles for logistics purposes	**To be collected during implementation** 1. Number of cargo units transported (1 unit = 1 pallet size) - independant of the loading limitation of an AV. 2. Number of attempts to book vehicles for logistics purposes - base on resquests made by actors on a dedicated booking platform	400 800	ER#14: Large scale AV trials of integrated MaaS and LaaS services in 3 sites across Europe (City & District of Herford, Geneva & Oslo) with ~45 AVs overall, for 12-36 months of seamless operation aiming to transport more than 50.000 passengers and 100.000 freight units.	0	150 300

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
A3	High	x					GA	special needs and inclusive passenger services	Classification of types of impairments that are supported to use the ULTIMO service	observation	from reports on newly developed services that are implemented the types of special needs persons we can serve : We consider the following impairment categories for Ultimo On Demand Services (persons with multiple impairments are not considered) : - without vision - with impaired vision - without colour perception - without hearing - with impaired hearing - with no or limited speech - with limited handling or strength - with limited reach - with limited cognitive, language or learning abilities Depending on the impairment, aids such as wheelchairs, rollators, white canes, crutches or guide dogs are used. The aim is to enable independent use of Ultimo On Demand Services (without assistance) in driverless operation. However, assistance services are currently required for safe transport, as there are still no standardised fixations for wheelchairs that are approved for use in public transport, for example. The assistance services are offered as transitional services to bridge any shortcomings. Corresponding Ultimo services are offered for the assistance services mentioned until they can be replaced by standardised standard solutions. With suitable training and individual training units for the different groups of people, the essential services in driverless operation will be accessible to experienced travellers (partly with assistance solutions) within the project framework, even if the level of comfort will certainly still need to be greatly improved.	We will have a vehicle in our fleet of on-demand vehicles dedicated for special needs transport.	4) Introduce special needs and inclusive passengers' services;	0	9 "9" will only be realisable for some user groups with a suitable assistance service
A4	Medium	x			x		GA	in-vehicle communication services	Number of in-vehicle communication services	counting	from reports on newly developed services that are implemented	Communication with a supervision centre should be atcheived	5) In-vehicle communication and services for user acceptance (like messages for passengers showing anxiety);	minimum 1	>=1

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
A5	Medium	x			x		GA	in-vehicle passenger safety services automated	Number of in-vehicle passenger safety incident types that can be handled automatically	counting	from reports on newly developed services that are implemented No specific number. It will depend of the user needs and feedback. We need to identify the incident types that public transport operators have today and see how many we can handle automatically.	Aggression, incident, ...	6) in-vehicle passenger safety and incident discouraging services (emergency stop, door locking, save haven itinerary, passenger behavior analysis etc),;	4	4
A6	Medium				x		GA	service hours per day	Number of passenger transport service hours per day	counting	from reports on services that are implemented		7) PT services 24/7 with strong guarantees for passenger (and vehicle!) safety	1 day per week	24h per day
A7	High	x			x		GA	reservation services	number of reservations per day in reservation services for shuttles	counting	data to be collected on the service tool this an option to be implemented in the fleet d reservation service and coordinated with fleet orchestaion, where for example large grops will need 3 buses in a short of convy service. Similarly to implement on-need based sending vehicle, that has an in-vehcielc opertor.	Increase in reservation numbers would be a huge plus.	Reservation services for individual passengers as well as reservation services for large groups (like school classes), as well as the vehicle follow-up. (. These type of services will allow the responsible "guardians" of kids or elderly with mild cognition problems, to safely take the bus and reach their destination)	0	Ruter: 450 per day TPG: 350 per day DB: 250 per day
A8	Low	x	x		x		GA	proactive alternative itineraries for passengers	Number of proactive alternative itineraries proposed to passengers	counting	data to be collected on the service tool The trip reservation will propose different options. This is a functionality we will offer, the passegfer will choose. So we "simply" enumarate the number of times a different options are offered (not always p[ossible), improvement of time and how many times the user choose what.	Can be tested, but I am not sure we have many alternatives avaialble today...	Test proactive alternative itineraries to passengers, in the cases of complex bus changes to reach a destination. The TPG central service will be able to propose to a registered passenger to change and take an automated vehicle at the next stop, which will shorten his travel time, without the passenger having asked for it.	0	1
A9	Medium		x		x		GA	new shuttle average integration time	average time to integrate a new type vehicle into the current fleet, once it has the standard API	measurement	data collected by PTOs	15 days	2) Quickly integrate new shuttles in the current fleet, despite the fact that they are from different manufacturers, (saving resources, money and time)	1 to 2 month	10 days
A10	Medium		x		x		GA	predictive maintenance and situation awareness for hardware repair time reduction	average time it takes to repair hardware components	estimation	data collected by PTOs data collection and estimation of repair time		3) Predictive maintenance and situation awareness services, allowing the operation at the back end to act pro-actively or early enough	2 months	1 week
A11	Mediu		x		x		G	predictive	average time it takes to resolve	estimation	data collected by PTOs		3) Predictive maintenance and	2-3	1 week

KPI Identifier	Priority (High/Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
	m						A	maintenance and situation awareness for software repair time reduction	software issues		data collection and estimation of repair time		situation awareness services, allowing the operation at the back end to act pro-actively or early enough	months	
A12	Low					x	GA	nationwide expansion within Germany	Number of PTOs using AVs in Germany	counting	data collected by DB Regio Bus theoretical study		4) New business models the ULTIMO presents that are in line with an important milestone in DB Regio Bus' strategy for automated driving in public transport: an economically robust system will accelerate the nationwide expansion within Germany	25 (Level 2-3)	10 PTA/PTO's in Germany
A13	High	x					GA	local engagement and acceptance	number of recurring (>5-times) users per service per site	counting	data collected by PTOs theoretical study of local authroities and promises		2) Local engagement and acceptance of new technology-based services;	0	Ruter: 500 TPG: 400 DB: 450
A14	High	x			x	x	GA	modernization of city stations	Number and density of flexible virtual pick-up and drop-off locations per site	counting	data collected by PTOs this will be a recommendation and cost estimation. Number of virtual stops and density (that will be higher than current bus stop density)		4) Continuous spatial planning and modernization of city stations, and flexible virtual pick-up and drop-off locations;	0	Ruter: 150 PUDOS, and <2 minutes to walk TPG: not envisaged DB: 75
A15	High	x			x		GA	(acceptable) detour time	detour time per ride	measurement	data collected by PTOs this is to be defined by the users in survey's	<5 min compared to optimal ETE/ETA	5) Acceptable detour time for users;	n/a	Optimal ETE/ETA + 10 minutes
A16	High		x		x		GA	AV dispatch time	time between booking and vehicle arrival	measurement	reports by PTOs this is the case today. We are interested in the delay to have the vehicle arrive. Depends on ara size and fleet size. It should be less than the current time plan based time between buses.		6) AVs will be dispatched in near real time;	30 min	Ruter: 15 min TPG: 30 min DB: 30 min
A17	High	x	x		x		GA	cost competitiveness of services	Cost of ULTIMO services and comparable other services Price for a ticket (passenger) for a certain ride Price for a freight delivery (unit cost)	Observation	check for the Benchmark ? Private car, taxi, existing public transport		9) Cost competitive services	current prices for PT	Ruter: Max 2x current ticket price TPG: current ticket prices DB: current ticket prices

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
A18	Low		x				GA	PTO costs	Cost for the PTO per passenger per trip Cost for public transport for the passenger per Km Cost of driver in public transportation % of total operation cost of a bus Cost per passenger per km Cost per shuttle per km	calculation	data collected by PTOs		1.9: Reduction of cost for PTOs:>30% (Sc)	Costs based on the Geneva "traditional" public transportation[11]	>30% reduction of cost
A19	High	x					GA	know-how exchange	number of projects / EU initiatives with know-how exchanges	counting	substantial exchanges, workshops, meetings, documents shared from the executive board with other initiatives/projects	5	6.2: Exchange of know-how with other EU initiatives and relevant projects: at least 5. (Sc)	0	>=5
A20	Low	x					GA	brochure downloads	number of downloads of the technical brochure posted on the ULTIMO website	counting		85	❖ Technical project brochure downloads: <25 = poor; 25-75 = good; >75 = excellent	0	>75
A21	High		x		x		GA	seamless full scale operation	number of days of outages of operation of the ULTIMO solution	counting	how many outages	2	ER#14: Large scale AV trials of integrated MaaS and LaaS services in 3 sites across Europe (City & District of Herford, Geneva & Oslo) with ~45 AVs overall, for 12-36 months of seamless operation aiming to transport more than 50.000 passengers and 100.000 freight units.	n/a	>70%

[11] Costs: based on the Geneva "traditional" public transportation
1. Cost for the PTO per passenger per trip : 1.98 CHF (where 1.20 CHF is public subvention)
2. Cost for public transport for the passenger: 0.22 CHF per passenger per Km
3. Cost of driver in public transportation: 40 to 64% of total operation cost of a bus
Costs of AV deployment: based on AVENUE evaluation D8.6
1. Cost per passenger per km : average of 0.99 EUR
2. Cost per shuttle per km : average 14.86 EUR

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
A22	High	x	x		x		GA	Number of passengers	Number of people transported throughout the project per automated vehicle/service type	Counting	Count per vehicle at pilot site level. Can also be reported via the monthly reports of the sites	45000	ER#14: Large scale AV trials of integrated MaaS and LaaS services in 3 sites across Europe (City & District of Herford, Geneva & Oslo) with ~45 AVs overall, for 12-36 months of seamless operation aiming to transport more than 50.000 passengers and 100.000 freight units.	0	50000
A23	Low		x		x		GA	logistics service use cases	number of use cases for logistics services implemented	counting the number of services and use cases tested successfully	**2 potential services identified :** - Urban logistics service extension (OVO uses AVs in it's operations) - Standalone urban logistics service (Any organisation uses AVs in it's operations and requests an AV through a digital booking platform) **6 potential uses cases identified :** - Click and AV for wholesalers - City Intralogistics for PoP, between PoP and PoS - City Logistics inventories between inventories from PoS - Multi-modal city logistics, supplying Nano-hubs and moving Nano-hubs (AV-hubs) - Suppliers automatic pick-up; on demand to deliver customers or planned from PoP to warehouse - Delivery to or from Logistic concierge service for eco-neighborhoods	2 4	2) Deployment of innovative logistics services using AV excess capacity from the TPG, as it includes households, local small shops and bigger agro-industrial enterprises, with high needs local urban logistics and transport deliveries	0	1 services 2 use cases
A24	Medium		x		x		GA	dynamic chartering of AV by non-PTO	number of dynamic charterings of AVs by non-PTO service providers	number of dynamic charterings of AVs by non-PTO service providers	reported by TPG/OVO		EO#23: Increase the use of dynamic chartering of AVs by non-PTO service providers by around 2-4% in the studied cities, by the end of the project	0	>1
A25	Low		x		x	x	GA	road maintenance costs	average cost for road maintenance in deployment sites	estimation	report WP6		EI#19: Financial benefits from reducing fuel consumption as well as **road maintenance costs**	0	0
A26	Medium				x	x	GA	predictive model accuracy	estimated accuracy of predictive model	observation		85%	1.2 Estimated accuracy of predictive model: >90% (Sc)	0.75	>85%
A27	Medium				x		GA	scheduling coordination (AV on demand)	Delay time of AVs	measurement	Different values to observe: Delay time Chance of routing during on booking and on the trip		4.1: Improvement of scheduling coordination optimisation: 5-10%. (Sc)	0	>5% improvement

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
											...				
A28	Medium				x		GA	AI event detection reliability	Percentage of reliability of AI for event detection compared to human classification (baseline data)	observation [reliability of AI in event detection]/[baseline data]*100 - 100		0.15	5.2: Percentage of reliability of AI for event detection compared to human classification: 20%. (Sc)	0.75	>85%
A29	High	x					GA	passenger satisfaction concerning safety	average passenger satisfaction concerning safety	survey		80%	1.6: Increase of passengers satisfaction concerning safety: >70% (Sc)	See footnote [12]	>70% increase
A30	Low	x	x				GA	Vandalisms	number of incidents involving vandalism	counting	reports for every incident	6	3.5: Decrease in number of frauds and incidents as vandalisms, health issues etc. : >30% (Sc)		<5
A31	High	x					GA	user acceptance	user acceptance rate of ULTIMO solutions	survey	number of users, and increasing numbers during the operation. Comparision of starting day numbers to last day numbers of users.	80%	5.3: User acceptance rates and public acceptance of the solutions increased by 20%. (Si, Sc)		>=20% increase
A32	Low				x		GA	transportation time	Average transportation time in ULTIMO relative to average transportation time before ULTIMO	[average transportation time ULTIMO]/[average transportation time before ULTIMO]	reports from PTOs	15 min	EO#4: Optimisation of transportation times (~15% reduction)	0	15% reduction
A33	High	x			x		GA	number of accidents	number of accidents in ULTIMO	observation/counting	Accidents can be reported via reports: 1. number of accidents 2. Type of accident	10	EO#5: Reduction of the Nr of accidents: 10% (20%) on average	0	0

[12] 1. It is not clear how autonomous e-minibuses react in unforeseen situations : 54% agreement
2. I would not feel secure in an automated minibus in case of harassment and assault : 43% agreement
3. The technology is not yet ready to drive on public roads : 31% agreement
1. transports made with public transportation 13 - 17% (depending on region : urban, rural) – (whereas private 38% and soft mobility 54%)
2. Average daily distance : total 25km, public transport 3.8 to 7.8 km (15-30%) (depending region : rural to urban)
3. Urban logistics night time delivery : 85% user acceptance for night reception (in distribution box)

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
A34	High	x			x		GA	Conflicts-Near miss incidents	Total number of conflicts-near miss incidents. A conflict is a critical traffic situation in which the intervention of the safety driver modifies vehicle`s trajectory or behavior preventing an accident with other vehicle or person or an extremely uncomfortable situations within the vehicle. The total number of conflicts-near miss incidents is recorded through the driver safety report.	estimation	Conflicts can be reported via reports	50	EO#7: Reduction of the Nr of critical situations on an average day: 10-20%	25 conflicts /1000 km	10-20% reduction
A35	High	x					GA	user satisfaction with AV	average of user satisfaction	survey		80%	EO#10: Increased overall user satisfaction and acceptance of the AVs in MaaS and LaaS services: > 90%	n/a	>90%
A36	Low	x		x			GA	night time deliveries	number of night-time (until 23:00) deliveries in deployment cities	counting	absolute number of night-time deliveries	2	EO#12: Increase the night-time deliveries (silent unloading) by around 2-3% in the studied cities, by the end of the project (this will increase parking availability in town centres, reduce traffic, improve mobility, etc.)	0	>1
A37	High	x					GA	passenger trust	Average user trust in ULTIMO solution	Survey		77% acceptance	EO#14: Increased trust of **passengers**/PTOs/Logistics service providers: > 90%	See footnote [13]	>90%
A38	low	x					GA	logistics services provider trust	Average logistics services provider trust in ULTIMO solution	Survey		77% acceptance	EO#14: Increased trust of passengers/PTOs/**Logistics service providers**: > 90%	See footnote [14]	>90%

[13] 1. Willingness to use AVs : Overall 63% acceptance and trust to use AVs.
2. Willingness to reduce use of private car (if it offers on-demand service) : 58%
3. Willingness to pay to use AVs (if it offers on-demand services) : 36%

[14] 1. Willingness to use AVs : Overall 63% acceptance and trust to use AVs.
2. Willingness to reduce use of private car (if it offers on-demand service) : 58%
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KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
A39	medium	x					GA	PTO trust	Average PTO trust in ULTIMO solution	Survey		77% acceptance	EO#14: Increased trust of passengers/**PTOs**/Logistics service providers: > 90%	See footnote [15]	>90%
A40	High				x		GA	Top speed of Avs	top speed reached by fastest AV deployed	measurement		50 km/h	6. It will deploy and assess in real traffic its services progressively…, …with operating speeds ranging from 18 to 60 km/h (at specific sites)…	20-25 km/h	DB: 60 km/h Oslo: 80 km/h TPG: 90 km/h
A41	High	x				x	GA	on board safety driver	rides/vehicles without an on-board safety driver	[number of rides without safety driver]/[number of rides]		80%	3. It will aim to minimise or even annihilate the role of the safety driver on-board…	0	1
A42	High	x					GA	scientific publications	number of papers submitted to peer-reviewed scientific publications	counting	submitted papers are tracked by the dissemination tracker	5	❖ Open Access to peer-reviewed scientific publications will be provided. ❖ **Number of papers submitted: <4 = poor, 4-8 = good, >8 = excellent** ❖ Number of conference presentations: <4 = poor, 4-8 = good, >8 = excellent	0	>=15

[15] 1. Willingness to use AVs : Overall 63% acceptance and trust to use AVs.
2. Willingness to reduce use of private car (if it offers on-demand service) : 58%
3. Willingness to pay to use AVs (if it offers on-demand services) : 36%

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
A43	High	x					GA	conference presentations	number of presentations held at conferences	counting	reports from UITP	8	❖ Open Access to peer-reviewed scientific publications will be provided. ❖ Number of papers submitted: <4 = poor, 4-8 = good, >8 = excellent ❖ **Number of conference presentations: <4 = poor, 4-8 = good, >8 = excellent**	0	>15
A44	Medium				x		GA	cyber attack impact	number of cyberattacks and hours of downtime due to cyber attacks	observation	reports for cyber attacks (don't forget regular backups)		3.8: Reduction of financial losses due to cyber attacks (Si)	n/a	0
A45	Medium		x	x	x		GA	AV lifetime	average projected lifetime of AVs in the deployment site fleets	estimation	analysis on reparability (cost of changing battery, etc)	12 years	ER#15: Extend the AV lifetime (from 6 to 12-15 years)	6 years	12-15 years
A46	High		x				GA	PTO dynamic chartering	income through dynamic chartering of AVs	estimation	dynamic chartering = on demand logistics services report and estimation. We more see reduction of costs		EO#25: Increased income for the PTOs by the dynamic chartering of the AVs and the partnerships created	n/a	n/a
A47	high		x				GA	operating costs of Logistics	operating costs for logistics services (only AV)	estimation	report based on estimations of costs and current costs per passenger.		EI#18: Financial benefits due to safer and more efficient transportation of goods	n/a	n/a
A48	Medium			x			GA	Energy use	Energy use per kilometre of a vehicle (g/km, J/km, or kWh/km)	theoretical calculation & test site measurement ?	Fuel consumption for ICE vehicles normalized over distance travelled. For electric vehicles battery consumption in J/km or kWh/km is necessary, otherwise provide battery consumption percentage and battery capacity in Wh(or kWh) or J. Battery consumption percentage alone is not sufficient		EI#19: Financial benefits from **reducing fuel consumption** as well as road maintenance costs	0.985 kWh/km	reduction
A49	High			x			GA	Climate change	GHG emissions	LCA (Life Cycle Assessment), results in CO2eq (CO2 equivalents)	The functional unit of the LCA is one pkm (= passenger kilometres, a metric of transport activity: when a single passenger travels a single kilometre, the result is 1 pkm of travel)		EI#20: Reduction of GHG emissions due to the implementation of ULTIMO solutions compared to existing conventional alternatives	CO2eq emissions of status quo (current situation)	reduction
A50	Medium			x			GA	Air pollution	emissions of air pollutants, PM levels, Nox, CO emissions	LCA (Life Cycle Assessment) that measures air pollutant emissions (e.g. PM10, PM2,5, NOx, from exhaust and non-exhaust and throughout entire life cycle)	The automated shuttle is a BEV, and during the use phase, BEVs have zero exhaust emissions, e.g. NOx and PM (European Environment Agency, 2018). However, BEVs emit PM locally from road, tyre and brake wear, like other motor vehicles (European Environment Agency, 2018). And it is important to mention that air pollutant emissions from BEVs occur for the electricity generation to charge BEV batteries and also from the production and enf-of-life phase. Nonetheless, the emissions from power stations tend to occur in less densely populated areas, provoking less human exposure to air pollution		EO#13: Reduced of **emissions** and noise pollution by replacing traditional busses with electrical AVs and reducing the use of private cars and trucks	emissions of status quo (current situation)	reduction

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-Non GA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
											than in urban areas (ibid). At the same time, the local emissions from combustion engine vehicles in cities provokes greater human exposure and potential health harm.				
B1	High				x		Non-GA	Average speed	Average speed of pilot vehicles in cities	avg_speed = mean(vehicle_speed)	Observations from 3 seconds before the scheduled stop until 8 seconds after should be excluded (see document provided by TNO)	15 km/h	EO#15: Percentage of AVs travelling within the speed limit increased by 10%.	Ruter: 22 km/h Average travel speed (with traditional public transport means) : 9.4km/h	Ruter: 22 km/h Same es current fleets of driver based busses = 18 to 20 km/h
B2	High	x					Non-GA	Website	number of website visits	counting/observation	the visits are tracked	500 visits	-	0	1st year 500, 2nd year 1000, 3rd year 2000, 4th year 2500
B3	High	x					Non-GA	News feeds	number of articles/news on project's and partners' websites	counting	tracked via the communication / dissemination tracker	10 articles/news	-	0	1st year 10, 2nd year 15, 3rd year 20, 4th year 25
B4	High	x					Non-GA	leaflet publications	number of project leaflets created number of project leaflets distributed	counting	There are 3 leaflets produced, 1 in the 1st year, 1 in the 3rd year, 1 in the 4th year. The number of leaflets distributed is thus related to the current leaflet in use	2 produced 1000 distributed	-	0	1st year 1 produced, 500 distributed 2nd year 0 produced, 1000 distributed 3rd year 1 produced, 500 distributed 4th year 1 produced, 1000 Distributed

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-Non GA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
B5	High	x					Non-GA	e-newsletter	number of newsletters sent out number of newsletter subscribers	counting	reported by UITP	2 newsletters sent 70 subscribers	-	0	1st year 1 sent, 60 subscribed 2nd year 2 sent, 100 subscribed 3rd year 2 sent, 150 subscribed 4th year 2 sent, 300 subscribed
B6	High	x					Non-GA	social media posts	number of social media posts	counting	posts are made on Twitter and LinkedIn	4 posts/month	-	0	1st year 4/month, 2nd year 5/month, 3rd year 8/month, 4th year 10/month,
B7	High	x					Non-GA	videos	number of videos created	counting	every video produced is reported by UITP	2 videos produced	-	0	1st year 1, 2nd year 0, 3rd year 1-3, 4th year 1
B8	High	x					Non-GA	attending events	number of events attended by ULTIMO consortium partners	counting	attended events are tracked by the dissemination tracker	8 events attended	-	0	1st year 6, 2nd year 15, 3rd year 25, 4th year 20
B9	Medium	x					Non-GA	event organisation	number of events organised by ULTIMO consortium partners	counting	organised events are tracked by the dissemination tracker	2 events organised	-	0	Y1: 4 Y2: 6 Y3: 6 Y4: 8
B10	High	x					Non-GA	press releases	number of press releases	counting	press releases are tracked by the dissemination tracker. Every press release distributed by multiple partners counts as 1 press release	2 press releases distributed	-	0	Y1 > 2 Y2 > 1 Y3 > 3 Y4 > 4
B11	Medium	x					Non-GA	Citizen co-creation	number of participants for co-creation events	counting		50 participants	-	0	25 per site and event

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
C1	High				x		Non-GA	High density mapping (RSD)	RSD coverage in pilot network	observation	reports from PTOs		-	0	94.6% (Ruter) 100% of the route that is driven (Gama)
C2	High			x	x		Non-GA	Spare parts guarantee	time horizon in which the delivery of spare parts is guaranteed	observation	reports from PTOs		-	10	15-30 years
C3	High	x					Non-GA	Number of handicapped users	Number of handicapped users of ULTIMI solutions	survey	number of users, and incresing numberrs during the operation. Comparision of starting day numbers to last day numbers of users.		-	0	25
C4	Low	x			x		Non-GA	Results availability	number of languages the ULTIMO results are translated in	counting	the pilot results have to be translated so they are available to the other sites	EN, GE, NW, FR, IT...	-	0	4
C5	High	x			x	x	Non-GA	AV integration in MaaS	level of integration of the new AV into a MaaS network	observation or self-evaluation of PTAs?	evaluation based on typology of Socher et al. (2018) https://doi.org/10.1016/j.rtbm.2018.12.003 Level 0: no integration single, separate services) Level 1: Integration of information (multimodal travel planner, price info) Level 2: Integration of booking & payment (single trip - find, book and pay) Level 3: Integration of the service offer (bundling/subscription, contracts etc.) Level 4: Integration of societal goals (policies, incentives etc.)	Level 4	-	0 or 1, depending on test site	3 or 4
C6	Medium	x					Non-GA	passenger security reaction time	average time it takes for help to arrive in case of harassment or assault	observation	time of call for help and time of arrival have to be traceable Also depends on local policies and laws.	5 min	-	0	<5 min
C7	High	x			x		Non-GA	Passenger comfortability levels	The passenger comfortability is based on the analysis of vehicle's performance data. The GPS data for speed is manipulated in order the acceleration value to be calculated, in the case that the specific sensor is not available. Based on the absolute	Post processing in GPS data (timestamp and speed are required)	Not uncomfortable <0.315m/s^2, Little Uncomfortable: 0.315/0.63 m/s^2, Fairly Uncomfortable: 0.5-1 m/s^2, Uncomfortable: 0.8-1.6m/s^2, Very Uncomfortable: 1.25-2.5m/s^2, Extremely Uncomfortable: 2-3m/s^2, Hard breaking event >3m/s^2	Not uncomfortable: 85%, Little Uncomfortable: 10%, Fairly Uncomfortable: 2.5%	-	Hard breaking events: 0.015%. The sum of the ranges	Hard breaking events: 0%. The sum of the ranges from Uncomforta

KPI Identifier	Priority (High/ Medium/Low)	Social	Economic	Environmental	Technical/Performance	Governance	GA-NonGA	KPI	Description	Calculation Method	Comments and Guidelines	Example	Excerpts from Proposal	Baseline	Target value
									acceleration values the following classes as percentages are calculated: Comfortable, Little Uncofortable, Fairly Uncofortable, Uncomfortable, Very Uncomfortable, Extremely Uncomfortable and Hard breaking event. This method has been defined and verified in terms of SHOW project			Uncomfortable: 1.25%, Very Uncomfortable: 0.75%, Extremely Uncomfortable: 0.035%, Hard breaking event: 0.001%		from Uncomfortable until the extremely uncomfortable 0.5% of the total acceleration values	ble until the extremely uncomfortable less than 0.005% of the total acceleration values

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